Jackson, Susank

From: Jackson, Susank
Sent: Wednesday, April 03, 2013 9:14 AM
To: Dolan, Mary; Pond, Greg
Cc: Symborski, Mark; Van Ness, Keith; Jeroen.Gerritsen@tetratech.com; Reynolds, Louis
Subject: Draft Report and attachments
Attachments: BCG report_preliminary review draft_April 3.docx; BCG and IBI Correspondence.pptx; Appendix B_Piedmont BCG.docx

Good morning. Attached is the draft report with two attachments (BCG and IBI comparison and Appendix B).

The report is preliminary. Your review comments are requested. We would like to finalize this report over the next month based on review by you and by the panelists.

Keith - can you review this report with a focus on the results and conclusions, provide us comments and then we can send to the expert panel for their review. Please email directly to Greg Pond and cc me. Greg is the "go to" technical person for this effort.

Both Greg and I will be available by email today if there are any changes or questions any of you on this draft. You may have some questions, edits or requests for further information for your meeting with the planning board tomorrow.

One last thing: If I recall correctly, there is a meeting next week. If you need a more final document by next week, please let us know. We can get the current draft cleaned abit more as well as the attachment formatted and incorporated directly into the body of the report. We would just need to know the timeframe.

Susan Jackson
US EPA Biological Criteria Program

Biological Condition Gradient:

A Headwater Steam Catchment in the Northern Piedmont Region, Montgomery County, Maryland

Technical Expert Workshop

Preliminary Report (first draft for review), April 3, 2013

Executive Summary

To be added

Note: This is a preliminary draft based on an expert panel evaluation (March 27, 2013) of a small data set. The results and conclusions will be reviewed by the expert panel before this report is finalized. Additional sections to be incorporated into this report include a table of contents, literature references, graphics and analysis depicting the relationship between the expert panel analysis (a preliminary biological condition gradient for Northern Piedmont Region streams) and Montgomery County biological indices for fish and macroinvertebrates, and a draft Biological Condition Gradient Table has been developed and is included in an appendix (appendix B). The latter two sections are currently draft and are included with this report as separate files.

Preliminary Report: Northern Piedmont Biological Condition Gradient for Montgomery County, Maryland

Why Is Measuring Biological Condition Important?

People care about the biota that live in their waters. For streams in the Northern Piedmont region of Montgomery County, Maryland, fish, mollusks, insects, amphibians and birds rely on a quality stream environment for at least one part of their life if not all. Additionally, a healthy aquatic community and a surrounding, intact watershed provide many social and economic benefits such as food, recreation and flood control. The Clean Water Act of 1972 reflects this public priority by establishing the national goal to restore and maintain the chemical, physical and ***biological integrity*** of the Nation's waters.

Biological assessments can be used to directly measure the overall biological integrity of an aquatic community and the synergistic effects of stressors on the aquatic biota residing in a waterbody (Figure 1-1) (USEPA 2003). Biological assessments are an evaluation of the biological condition of a waterbody using surveys of the structure and function of resident biota. The biota functions as continual monitors of environmental quality, increasing the sensitivity of our assessments by providing a continuous measure of exposure to stressors and access to responses from species that cannot be reared in the laboratory. This increases the likelihood of detecting the effects of episodic events (e.g., spills, dumping, treatment plant malfunctions), toxic nonpoint source (NPS) pollution (e.g., agricultural pesticides), cumulative pollution (i.e., multiple impacts over time or continuous low-level stress), nontoxic mechanisms of impact (e.g., trophic structure changes due to nutrient enrichment), or other impacts that periodic chemical sampling might not detect. Biotic response to impacts on the physical habitat such as sedimentation from stormwater runoff and physical habitat alterations from dredging, filling, and channelization can also be detected using biological assessments.

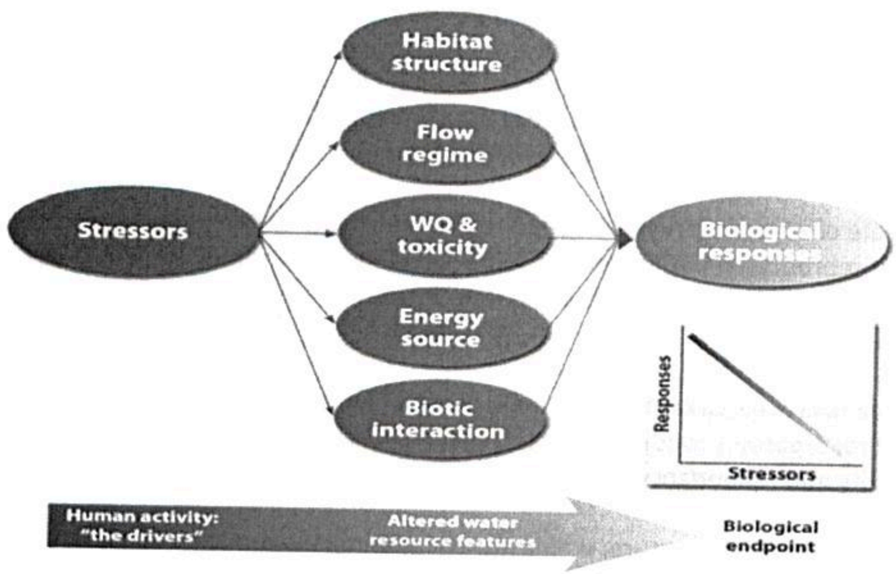


Figure 1-1. Biological assessments provide information on the cumulative effects on aquatic communities from multiple stressors. Figure courtesy of David Allen, University of Michigan.

The Biological Condition Gradient

The Biological Condition Gradient (BCG) is a conceptual, narrative model that describes how biological attributes of aquatic ecosystems change along a gradient of increasing anthropogenic stress. It provides a framework for understanding current conditions relative to natural, undisturbed conditions. Some states, such as Maine and Ohio, have used a BCG framework to more precisely define their designated aquatic life uses, monitor status and trends, and track progress in restoration and protection (USEPA 810-R-11). These two states and many others have used biological assessments and BCG-like models to support water quality managements over several decades. Based on these efforts, USEPA worked with biologists from across the United States to develop the BCG conceptual model (Davies and Jackson 2006.) The BCG shows an ecologically based relationship between the stressors affecting a waterbody (the physical, chemical, biological impacts) and the response of the aquatic community, manifested as the biological condition. The model can be adapted or calibrated to reflect specific geographic regions and waterbody type (e.g., streams, rivers, wetlands, estuaries, lakes). Approaches to calibrate the BCG to region-, state-, or tribe-specific conditions have been applied in several ecological regions by multiple states and tribes.

In practice, the BCG is used to first identify the critical attributes of an aquatic community and then describe how each attribute changes in response to stress. Practitioners can use the BCG to interpret biological condition along a standardized gradient regardless of assessment method and apply that information to different state or tribal programs. For example, Pennsylvania is using a BCG calibrated to its streams to identify exceptional and high-quality waters based on biological condition (exceptional waters may also be identified with other criteria, say, scenic or recreational value) (USEPA 810-R-11)

The BCG is divided into six levels of biological conditions along the stressor-response curve, ranging from observable biological conditions found at no or low levels of stress (level 1) to those found at high levels of stress (level 6) (Figure 1-2):

Level 1. Native structural, functional, and taxonomic integrity is preserved; ecosystem function is preserved within range of natural variability. Level 1 describes waterbodies that are pristine, or biologically indistinguishable from pristine condition.

Level 2. Virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability.

Level 3. Some changes in structure due to loss of some highly sensitive native taxa; shifts in relative abundance of taxa but sensitive–ubiquitous taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system, but may differ quantitatively.

Level 4. Moderate changes in structure due to replacement of sensitive–ubiquitous taxa by more tolerant taxa, but reproducing populations of some sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes.

Level 5. Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased buildup or export of unused organic materials.

Level 6. Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor (e.g. diseased individuals may be prevalent); ecosystem functions are severely altered.

The Biological Condition Gradient: Biological Response to Increasing Levels of Stress

Levels of Biological Condition

Level 1. Natural structural, functional, and taxonomic integrity is preserved.

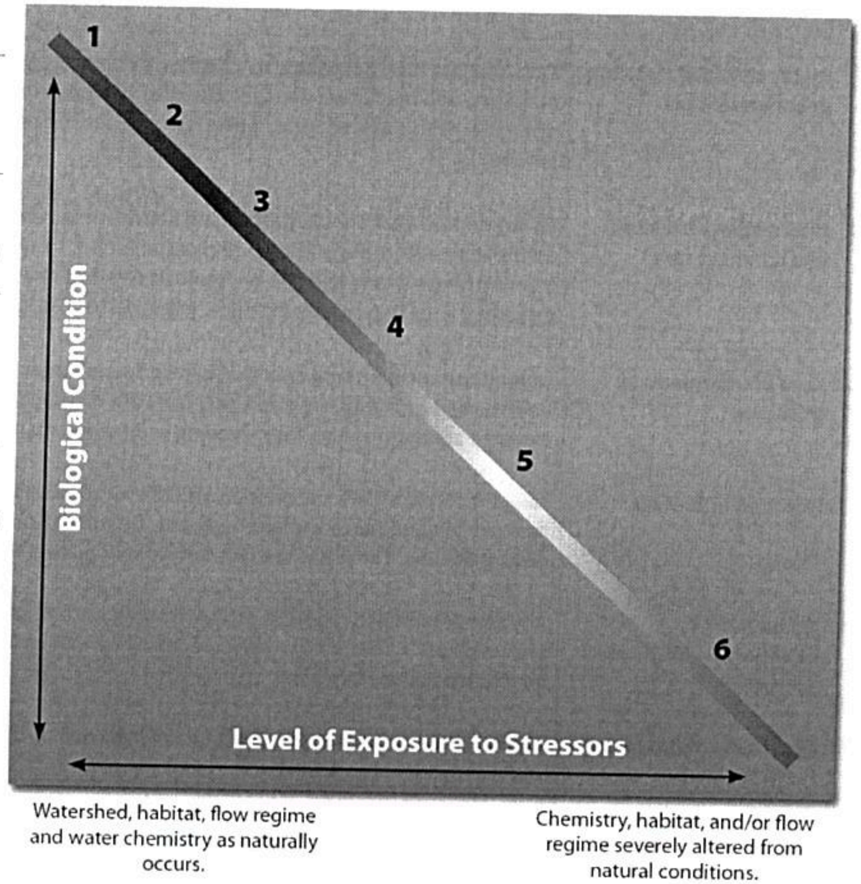
Level 2. Structure & function similar to natural community with some additional taxa & biomass; ecosystem level functions are fully maintained.

Level 3. Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained.

Level 4. Moderate changes in structure due to replacement of some sensitive ubiquitous taxa by more tolerant taxa; ecosystem functions largely maintained.

Level 5. Sensitive taxa markedly diminished; conspicuously unbalanced distribution of major taxonomic groups; ecosystem function shows reduced complexity & redundancy.

Level 6. Extreme changes in structure and ecosystem function; wholesale changes in taxonomic composition; extreme alterations from normal densities.



Source: Modified from Davies and Jackson 2006
Figure 1-2. The Biological Condition gradient (BCG).

The scientific panels that developed the BCG conceptual model identified 10 attributes of aquatic ecosystems that change in response to increasing levels of stressors along the gradient, from level 1 to 6 (see Table 1). The attributes include several aspects of community structure, organism condition, ecosystem function, spatial and temporal attributes of stream size, and connectivity.

Each attribute provides some information about the biological condition of a waterbody. Combined into a model like the BCG, the attributes can offer a more complete picture about current waterbody conditions and also provide a basis for comparison with naturally expected waterbody conditions. All states and tribes that have applied a BCG used the first seven attributes that describe the composition and structure of biotic community on the basis of the tolerance of species to stressors and, where available, included information on the presence or absence of native and nonnative species and, for fish and amphibians, observations on overall condition (e.g., size, weight, abnormalities, tumors).

Table 1. Biological and other ecological attributes used to characterize the BCG.

Attribute	Description
I. Historically documented, sensitive, long-lived, or regionally endemic taxa	Taxa known to have been supported according to historical, museum, or archeological records, or taxa with restricted distribution (occurring only in a locale as opposed to a region), often due to unique life history requirements (e.g., sturgeon, American eel, pupfish, unionid mussel species).
II. Highly sensitive (typically uncommon) taxa	Taxa that are highly sensitive to pollution or anthropogenic disturbance. Tend to occur in low numbers, and many taxa are specialists for habitats and food type. These are the first to disappear with disturbance or pollution (e.g., most stoneflies, brook trout [in the east], brook lamprey).
III. Intermediate sensitive and common taxa	Common taxa that are ubiquitous and abundant in relatively undisturbed conditions but are sensitive to anthropogenic disturbance/pollution. They have a broader range of tolerance than Attribute II taxa and can be found at reduced density and richness in moderately disturbed sites (e.g., many mayflies, many darter fish species).
IV. Taxa of intermediate tolerance	Ubiquitous and common taxa that can be found under almost any conditions, from undisturbed to highly stressed sites. They are broadly tolerant but often decline under extreme conditions (e.g., filter-feeding caddisflies, many midges, many minnow species).
V. Highly tolerant taxa	Taxa that typically are uncommon and of low abundance in undisturbed conditions but that increase in abundance in disturbed sites. Opportunistic species able to exploit resources in disturbed sites. These are the last survivors (e.g., tubificid worms, black bullhead).
VI. Nonnative or intentionally introduced species	Any species not native to the ecosystem (e.g., Asiatic clam, zebra mussel, carp, European brown trout). Additionally, there are many fish native to one part of North America that have been introduced elsewhere.
VII. Organism condition	Anomalies of the organisms; indicators of individual health (e.g., deformities, lesions, tumors).
VIII. Ecosystem function	Processes performed by ecosystems, including primary and secondary production; respiration; nutrient cycling; decomposition; their proportion/dominance; and what components of the system carry the dominant functions. For example, shift of lakes and estuaries to phytoplankton production and microbial decomposition under disturbance and eutrophication.
IX. Spatial and temporal extent of detrimental effects	The spatial and temporal extent of cumulative adverse effects of stressors; for example, groundwater pumping in Kansas resulting in change in fish composition from fluvial dependent to sunfish.
X. Ecosystem connectance	Access or linkage (in space/time) to materials, locations, and conditions required for maintenance of interacting populations of aquatic life; the opposite of fragmentation. For example, levees restrict connections between flowing water and floodplain nutrient sinks (disrupt function); dams impede fish migration, spawning. Extensive burial of headwater streams leads to cumulative downstream impacts to biota through energy input disruption, habitat modification, and loss of refugia and dispersing colonists

Source: Modified from Davies and Jackson 2006.

The last three BCG attributes of ecosystem function, connectance, and spatial and temporal extent of detrimental effects can provide valuable information when evaluating the potential for a waterbody to be protected or restored. For example, a manager can choose to target resources and restoration activities to a stream where there is limited spatial extent of stressors or there are adjacent intact wetlands and stream buffers or intact hydrology versus a stream with comparable biological condition but where adjacent wetlands have been recently eliminated, hydrology is being altered, and stressor input is predicted to increase.

The BCG model provides a framework to help water quality managers do the following:

Decide what environmental conditions are desired (goal-setting)—The BCG can provide a framework for organizing data and information and for setting achievable goals for waterbodies relative to "natural" conditions, e.g., condition comparable or close to undisturbed or minimally disturbed condition.

Interpret the environmental conditions that exist (monitoring and assessment)—managers can get a more accurate picture of current waterbody conditions.

Plan for how to achieve the desired conditions and measure effectiveness of restoration—The BCG framework offers water program managers a way to help evaluate the effects of stressors on a waterbody, select management measures by which to alleviate those stresses, and measure the effectiveness of management actions.

Communicate with stakeholders—When biological and stress information is presented in this framework, it is easier for the public to understand the status of the aquatic resources relative to what high-quality places exist and what might have been lost.

Specifically, biological assessment information has been used by federal, state, tribal and local governments to:

- ***Define goals for a waterbody***—Information on the composition of a naturally occurring aquatic community can provide a description of the expected biological condition for other similar waterbodies and a benchmark against which to measure the biological integrity of surface waters. Many states and tribes have used such information to more precisely define their designated aquatic life uses, develop biological criteria, and measure the effectiveness of controls and management actions to achieve those uses.
- ***Report status and trends***—Depending on level of effort and detail, biological assessments can provide information on the status of the condition of the expected aquatic biota in a waterbody and, over time with continued monitoring, provide information on long-term trends.
- ***Identify high-quality waters and watersheds***—Biological assessments can be used to identify high-quality waters and watersheds and support implementation of antidegradation policies.
- ***Document biological response to stressors***—Biological assessments can provide information to help develop biological response signatures (e.g., a measurable, repeatable response of specific species to a stressor or category of stressors). Examples include sensitivity of mayfly species (pollution-sensitive aquatic insects) to metal toxicity or temperature-specific preferences of fish species. Such information can provide an additional line of evidence to support stressor identification and causal analysis (USEPA 2000a), as well as to inform numeric criteria development (USEPA 2010a).

For further information and examples of implementation, see *A Primer on Using Biological Assessments to Support Water Quality Management*, EPA 810-R-11-01. Calibrating the Conceptual Model to Local Conditions

Calibrating the Conceptual BCG Model to Local Conditions

The BCG can serve as a starting point for defining the response of aquatic biota to increasing levels of stress in a specific region. The model can be applied to any region or waterbody by calibrating it to local conditions using specific expertise and local data. To date, most states and tribes are calibrating the BCG using the first seven attributes that characterize the biotic community primarily on the basis of tolerance to stressors, presence/absence of native and nonnative species, and organism condition.

A multistep process is followed to calibrate a BCG to local conditions (Figure 1-3); to describe the native aquatic assemblages under natural conditions; to identify the predominant regional stressors; and to describe the BCG, including the theoretical foundation and observed assemblage response to stressors. Calibration begins with the assembly and analysis of biological monitoring data. Next, a calibration workshop is held in which experts familiar with local conditions use the data to define the ecological attributes and set narrative statements; for example, narrative decision rules for assigning sites to a BCG level on the basis of the biological information collected at sites. Documentation of expert opinion in assigning sites to tiers is a critical part of the process. A decision model can then be developed that encompasses those rules and is tested with independent data sets. A decision model based on the tested decision rules is a transparent, formal, and testable method for documenting and validating expert knowledge. A quantitative data analysis program can then be developed using those rules.

BCG Development for Montgomery County

Montgomery County convened a panel of 17 technical experts consisting of stream and fisheries biologists and aquatic ecologists to develop a BCG conceptual model for the Piedmont region of Maryland (see list of panel members). The panel participated in several webinars/ conference calls, and an all-day panel meeting on March 27, 2013. The objective was to develop a BCG narrative model, including narrative descriptions of the BCG levels as they are manifested in the Piedmont region of Maryland, and using data collected by Montgomery County.

The County developed a Benthic Index of Biotic Integrity (B-IBI) and a Fish Index of Biotic Integrity (F-IBI) in 1998 as a way to rate and compare local streams. Narrative categories of ' excellent', 'good', 'fair' and 'poor' were used. These stream categories were used in the Countywide Stream Protection Strategy, County Master Plans, and in the annual SPA Reports. Local officials and the public understood and accepted this concept. Soon, however, people began to describe streams as 'high' good or 'low' excellent and began to ask what would be needed to improve streams from 'poor' to 'good'. In order to try and answer this question, the individual metrics and other information on the biological community structure and function of the biotic community had to be taken from the IBI's. A better tool was sought that would provide more refined and detailed information on streams and their response to land use change. The BCG appeared to be that tool and a pilot evaluation was sought to see how the BCG would rate streams representing a wide range of conditions.

Identifying BCG Attributes

Biologists have long observed that taxa differ in their sensitivity to pollution and disturbance. While biologists largely agree on the relative sensitivity of taxa, there may be subtle differences among stream types (high vs. low gradient) or among geographic regions. The workgroup participants used their collective experience and judgment to assign sensitivities of the organisms to the disturbance gradient. Participants discussed the fish and benthic macroinvertebrates that occur in Montgomery County and in Maryland's Piedmont, and developed a consensus assignment prior to the workshop. Examples are shown in Tables 2 and 3, and Figure 3.

Table 2. Examples of Northern Piedmont fish and salamanders by attribute group.

Ecological Attribute	Number of species	Example Species
I Endemic, rare	5	Brook trout, bridle shiner, Chesapeake log perch, Maryland darter, trout perch
II Highly Sensitive	7	Yellow perch, northern hog sucker, margined mad tom, dusky salamander, longtailed salamander
III Intermediate Sensitive	11	Fallfish, fantail darter, Potomac sculpin, Blue Ridge sculpin
IV Intermediate Tolerant	14	Channel catfish, least brook lamprey, pumpkinseed, tessellated darter
V Tolerant	13	American eel, mummichog, white sucker, sea lamprey, northern two-lined salamander
VI-i Sensitive Nonnative	2	brown trout, rainbow trout
VI-m Intermediate nonnative	6	Black crappie, golden redhorse, smallmouth bass
VI-t Tolerant nonnative	6	common carp, goldfish, green sunfish, largemouth bass, snakehead
x unassigned		Unidentified fish, hybrids

Table 3. Examples of Northern Piedmont benthic macroinvertebrates by attribute group.

Ecological Attribute	Number of taxa	Example Species
I Endemic, rare		None attributed
II Highly Sensitive	~50	Mayflies: *Habrophlebia, Epeorus, Ephemera, Leucrocuta, Habrophlebiodes, Paraleptophlebia,* Stoneflies: *Sweltsa, Talloperla, Eccoptura,* Caddisflies: *Wormaldia, Diplectrona, Rhyacophila, Dolophilodes,* Flies: *Dixa,* Prodiamesinae
III Intermediate Sensitive	~60	Mayflies: *Diphetor, Ephemerella, Ameletus, Serratella,* Stoneflies: *Amphinemura, Acroneuria, Leuctra, Isoperla,* Dragonflies: *Cordulegaster, Lanthus,* Caddisflies: *Neophylax, Rhyacophila, Pycnopsyche, Glossosoma,* Beetles: *Oulimnius, Anchytarsus,* Flies: Diamesinae, *Hexatoma, Prosimulium*
IV Intermediate Tolerant	>100	Mayflies: *Baetis, Stenonema,* Damsel and Dragonflies: *Calopteryx, Boyeria,* Caddisflies: *Hydropsyche, Polycentropus,* Beetles: *Helichus, Optioservus,* Fishflies: *Nigronia,* Other: *Chelifera,* Tanytarsini, *Tipula, Tabanidae, Crangonyx,* Enchytraeidae
V Tolerant	>50	Beetles: Hydrophilidae, Dytiscidae, Flies: *Hemerodromia,* most Chironomini and Orthocladiinae, Stratiomyiidae, Other: Isopoda, Physidae, Hirudinae, Tubificidae
V Nonnative	2	Asian Clam: *Corbicula,* Snails: *Bithnya*
x Unassigned		Ambiguous family-level or order-level identifications, unknown tolerance

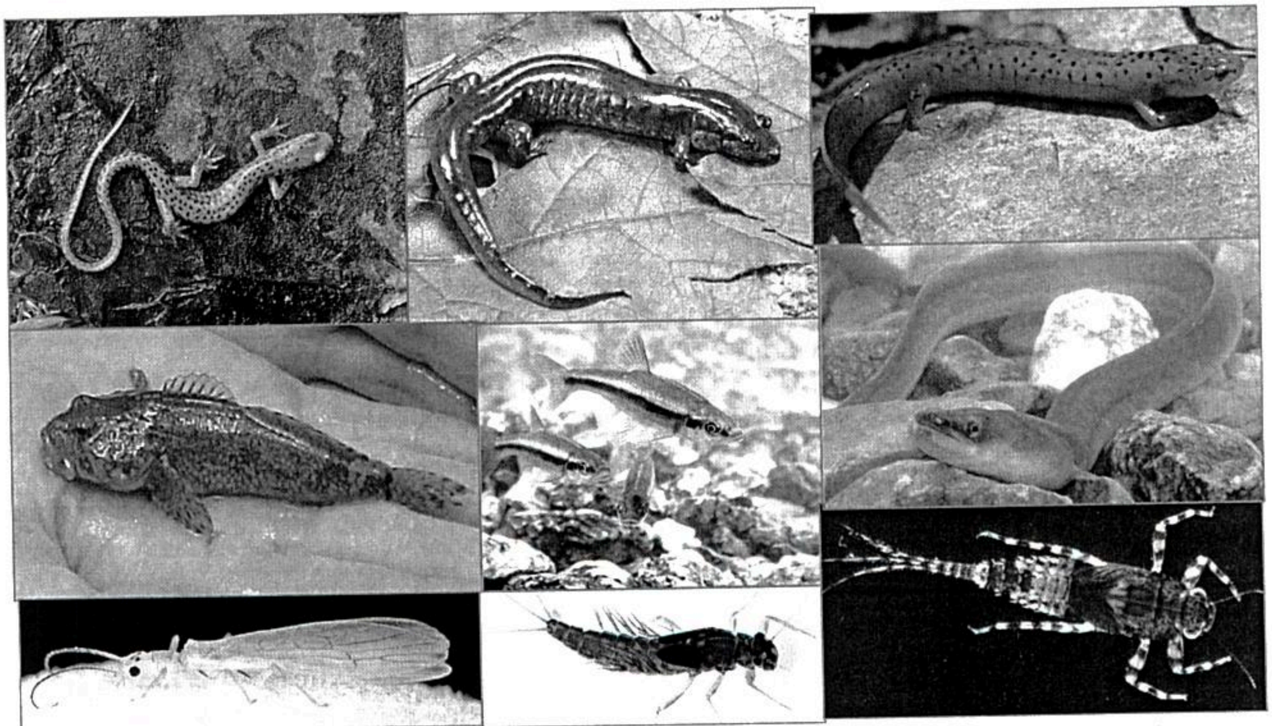


Figure 3. Important aquatic species in Maryland's Piedmont headwater streams. Salamanders (Long-tailed, Dusky, and Red); fishes (Potomac Sculpin, Rosyside Dace, American Eel); Insects (Sweltsa, *Paraleptophlebia*, *Ephemerella*).

Expert Solicitation: Determining BCG Levels

Panelists examined biological data from individual sites and assigned those samples to Levels 1 to 6 of the BCG. The intent was to achieve consensus and, in the process, to document the scientific rationale that experts were using to make their assignments. Expert solicitation is the first step in a rigorous, transparent process to develop quantifiable rules for decision making and model development. The end result is the refinement of existing , or development of new, biological indices. Though the first step in a longer process, expert evaluation of changes in taxa, in-stream and riparian habitat, and watershed condition can yield immediate detail and insight on the response of local and regional biota to increasing stress. This information can be used to identify high quality waters that maybe threatened and require additional protection and waters that show early signs of degradation but where protection or restoration efforts could be most efficient and successful.

The data that the experts examined when making BCG level assignments were provided in worksheets. The worksheets contained lists of taxa, taxa abundances, BCG attribute levels assigned to the taxa, BCG attribute metrics and limited site information (e.g., such as watershed area), size class (i.e., headwater), and stream gradient. Participants were not allowed to view Station IDs or waterbody names when making BCG level assignments, as this might bias their assignments. Fish and macroinvertebrate worksheets can be found in Appendix C.

The workgroup examined macroinvertebrate data from 16 samples, and fish data from 17 samples. The group was able to reach a consensus opinion on the BCG level assignments for all sites reviewed. The panels were able to distinguish 4 separate BCG levels (BCG Levels 3-6), although Level 6 (extreme degradation) was rare. The experts also identified significant changes in assemblages the indicated shifts either up or down along the gradient. For example, the fish group identified a sample that was borderline between Levels 2 and 3, that is, half of the experts assessed the samples at Level 2 - and half at Level 3+ . All agreed that these sites were borderline between the two levels because of excellent habitat and water quality conditions and potential for these sites to support native or other sensitive species that were currently missing e.g. brook trout. The macroinvertebrate group identified three samples that they considered borderline Level 2-3 because the expected sensitive and native taxa were either absent or present in low numbers and the in-stream habitat and water quality were judged sufficient or close to sufficient to support these taxa. Additionally, the level of disturbance in the immediate watershed area was low and restoration potential for these sites judged excellent.

The experts discussed the transitions between levels; that is, what is changed or lost between a higher level to a lower level. The expert's rationale on what constituted a significant change or loss of the biotic community was recorded. The descriptions of the transitions become the basis for the next step in development of a quantitative BCG model, the development of narrative decision criteria for assigning sites to BCG levels.

Level 1 – Level 2 Natural Conditions (undisturbed to minimally disturbed). The panel felt that Level 1 sites, which are indistinguishable from pristine or undisturbed, would have strictly native taxa for all assemblages evaluated (fish, salamander, benthic macroinvertebrates) with no (non-natives present, some endemic species, and evidence of connectivity in the form of migratory fish. The presence of non-native species and loss of endemic species would move a site to the next level down on the gradient, Level 2. However, there are no sites within the piedmont that do not have some degree of disturbance, including legacy effects from agriculture and forestry from 100 to 200 years ago. This is typical situation for most of the North American continent. For practical reasons, Level 1 and highly rated level 2 (e.g. 2+) have been combined. These sites have excellent water quality and support habitat critical for native taxa. For macroinvertebrates, Level 2+ sites would have many highly sensitive taxa and relatively high richness and abundance of intermediate sensitive-ubiquitous taxa. Many of these taxa are characterized by having limited dispersal capabilities or are habitat specialists. Tolerant taxa are present but have low abundance. Presence of sensitive-rare, cold water indicator taxa such as the mayfly *Epeorus*, and stoneflies *Sweltsa* and *Talloperla* would be expected to occur.

Level 2 Near Natural (minimally disturbed). For fish, the panel decided that non-native species may be present, but they cannot exclude native species. A site that would be assigned to Level 2 must also maintain connectivity between the mainstem, associated wetlands and headwater streams so that migratory fish and amphibians (e.g., eel, lamprey, salamanders) are present or known to access the site. Native top predators (e.g. brook trout) are present. The best fish site (upper Patuxent River) lacked brook trout, but reintroduction of reproducing native brook trout and access for migratory fish would raise this site to Level 2 status. Several sites rated as BCG level 3 supported habitat and water quality that would support a reproducing native brook population. These sites would then be rated as a level 2. The Long-tailed and Dusky salamanders were noted as two amphibians that panelists agreed would also help indicate Level 2 Piedmont streams given a complimentary fish community. Macroinvertebrate panelists believed that presence of several key taxa would help indicate Level 2 streams, especially coldwater indicator mayflies, stoneflies, and caddisflies (e.g, *Epeorus*, *Paraleptophlebia*, *Sweltsa*, and *Wormaldia*).

Level 3 Near Natural Habitat (loss of native taxa). Level 3 condition was generally considered a good quality condition by the panel. For macroinvertebrates, Level 3 sites should have several highly sensitive taxa and relatively high richness and abundance of intermediate sensitive-ubiquitous taxa. Taxa with intermediate tolerance may increase in richness and abundance. Tolerant taxa are somewhat more common but still have low abundance. Key sensitive taxa include the caddisfly *Diplectrona*, the mayfly *Ephemerella* and the stonefly *Amphinemura*. Panelists expected other key taxa to indicate Level 2 streams, especially coldwater indicator mayflies, stoneflies, and caddisflies (e.g, *Epeorus*, *Sweltsa*, and *Wormaldia*).

Level 3 – Level 4. For fish, the transition from Level 3 to Level 4 is characterized by increasing loss of sensitive species, and by increased abundance of tolerant species indicating nutrient enrichment and/or excess sedimentation. Salamander taxa would include the more generalist or tolerant Red Salamander and Two-lined Salamander, but sensitive Dusky may also occur. For macroinvertebrates, panelists agreed that as sites slipped toward Level 4, that highly sensitive macroinvertebrate taxa were more poorly represented but some intermediate sensitive-ubiquitous taxa populations were maintained. Although cool and coldwater indicator taxa such as *Dolophilodes*, *Diplectrona* and *Leuctra* are usually present, obvious increases in intermediate-tolerance and tolerant individuals were noted when compared to Level 2-3, driven primarily by increases in specific chironomid midgefly subfamilies.

Level 4 Significant Alteration in Aquatic Biota (Moderately Disturbed). Sensitive species and individuals are still present but in reduced numbers (e.g., approximately 10 – 30% of the community rather than 50% found in Level 3 streams). The experts generally agree that the persistence of some sensitive species indicates that their original ecosystem function is still maintained albeit at a reduced level. For example, Level 4 streams may have sculpins, but non-native species occur more frequently. Similarly, macroinvertebrate taxa such as *Diplectrona* and *Dolophilodes* may occur, but other key taxa such as *Ephemerella* and *Neophylax* are absent. These streams may harbor 2 to 3 salamander species (Dusky, Red, and Two-lined).

Level 4 – Level 5. The panel considered sites rated towards the lower end of Level 4 (e.g. approximately 10 - 15% of the sensitive species present) to be trending towards a markedly diminished aquatic community characteristic of the next level down, Level 5. Tolerant taxa predominant and sensitive species are either absent or present in very low numbers. Though not part of this evaluation, there can be increased evidence of physiological stress. Most notably in fish and amphibian communities, lesions, tumors, and other abnormalities are increasingly observed.

Level 5 Major Alteration in Aquatic Biota (Major level of disturbance). In Level 5, sensitive species and individuals may be present but their functional role is negligible within the system. Those sensitive taxa remaining are highly ubiquitous ones within the region having very good dispersal capabilities. Tolerant Two-lined salamanders might be the only salamander present. For macroinvertebrates, streams trending toward Level 5 revealed that highly sensitive macroinvertebrate taxa were usually absent and

Chironomid midges (mostly tolerant Orthocladiinae and Chironomini) often comprised >50% of the community in Level 5 streams. Level 5 typically has abundant organisms that are mostly tolerant or intermediate tolerance, both native and introduced, and may have relatively high diversity within the tolerant organisms. Macroinvertebrate communities could have high or low overall diversity, but most representatives are opportunistic or pollution tolerant species.

Level 5 – Level 6. Transition from level 5 to level 6 is characterized by loss of remaining diversity to a depauperate community. Some highly tolerant organisms such as fathead minnows, brown bullhead, various maggot genera, tubificid and naidid worms, or physid snails may be very abundant, indicating extreme organic enrichment and hypoxia; or extreme low abundance and low richness of all organisms may indicate toxic conditions. Under hypoxic conditions, only those tolerant invertebrates adapted to living in low dissolved oxygen or can breathe atmospheric air may be present.

Level 6 Severe Alteration in Aquatic Biota (Extreme level of disturbance). In the Piedmont, these streams are heavily degraded from urbanization and/or industrialization and can range from having no aquatic life at all or harbor a severely depauperate community composed entirely of highly tolerant or tolerant invasive species adapted to hypoxia, extreme sedimentation and temperatures, or other toxic chemical conditions. In our exercise, panelist ratings were mixed for a couple of sites where some indicated a 6 while others indicated 5-. Experts who did not rate the site as a 6 indicated that the stream could get even worse.

Results

A preliminary BCG based on benthic macroinvertebrates, fish and salamander assemblages has been developed (Appendix B and see Table 4 at end of this section for an abbreviated version). The BCG is based on macroinvertebrate, fish and salamander assemblages in 1st to 3rd order streams (1:24,000 scale) with catchment areas ranging from 0.5 to 5 mi^2. The panelists working with the fish and salamander assemblages rated the 17 selected sites from BCG Level 3+ to 6. The 16 macroinvertebrate sites were rated roughly from 2- to 6+. Where both sets of sites overlapped (sites with both assemblages), there was relatively good agreement. For example, at Samp002 the fish experts rated the site a 4 while the macroinvertebrate experts rated it as a 3-. Similarly, Samp012 was rated a 6+ by fish panelists and a 5- by macroinvertebrate specialists. At Samp004, both groups of panelists rated the site a solid Level 3. The rationale for assignment of each sample was documented and among the assemblage groups, there was consistent agreement on basis for the assignments. The rationale for the assignments becomes the basis for development of narrative decision rules to BCG level assignment. In turn, with further testing and peer review, these narrative statements then become the basis for quantification and development of numeric biological indices or models.

Ten Mile Creek sites ratings ranged between the high end of BCG level 3 (e.g. a 3+) to BCG level 4. For most BCG level development done to date, sites that are comparable to BCG level 4 are often judged as attaining their designated aquatic life use. Several of the Ten Mile Creek sites, particularly the primary head water streams, were judged as very good quality, receiving a low BCG level 2 rating (e.g. 2-) or high BCG level 3 rating (e.g. 3+). The experts felt that these streams have excellent potential for improvement to BCG level 2 if protected with options for additional protection considered.

The information provided by each of the assemblages was complementary, each providing additional insight into the current condition as well as potential for restoration. For example, for several sites there were cool and cold water sensitive benthic macroinvertebrate taxa present as well as sensitive salamander species. The native brook trout were not present at these sites but because of the presence of these other assemblages indicative of good water quality and habitat, these streams c may be able to support a self-sustaining native brook trout population and be a candidate for an upgrade from their current use class, class # 1, to class # 3. These sites are approaching and may achieve conditions comparable to Northern Piedmont Sentinel sites that, as of this date, occur only outside of the county.

Three of the sites were split into "before and after" sets that were rated by both groups (this information was not provided to the panelists).

1.) Clarksburg Tributary was sampled twice, 14 years apart (1998 and 2012); panelists rated the macroinvertebrate community as a 3 to 3- before residential development and a 4- after development. The abundance of sensitive taxa declined from 86% to 28% while tolerant taxa increased from 5% to 64%. However, the panelists believed that the stream had retained some sensitive taxa and thus did not rate the site a 5.

2.) Right Fork was also initially sampled in 1998 prior to extensive urbanization and was re-sampled in 2012. Macroinvertebrates changed from a Level 2+ stream to a 4-; some highly sensitive, cool and coldwater invertebrate taxa (*Diplectrona, Dolophilodes, Eccoptura*) and some intermediate sensitive taxa (e.g., *Ephemerella*)were eradicated following urbanization. For fish, this site changed from a 3 to a 3- having similar species composition but had experienced large increases in abundance of the tolerant Blacknose Dace.

3.) Piney Branch fishes were sampled 15 yrs apart (before and after extensive urbanization). Experts rated the "before" data as a 3- (3s and 4s) and the "after" data as a 4- (4s and 5s). Here, sensitive taxa dropped from 52% to 9% (mostly loss of sculpins) while tolerants (both native and non-native) increased from 44% to 89%.

Comparison of BCG level assignments and IBI scores

See attachment: BCG and IBI Correspondence, to be incorporated into report this week. Under review and needs formatting assistance!

Table 4.	Biological Condition Gradient: description of biological communities in Northern Piedmont streams (Montgomery County, Maryland)
	I *Historically documented, sensitive, long-lived, or regionally endemic taxa:* Depending on size of stream, one or more of the following are present: Vertebrates: Bridle Shiner, Brook Trout, Chesapeake Logperch, Maryland Darter, Trout Perch. May be absent in very small headwaters.
1	II *Highly Sensitive taxa:* Depending on size of stream, one or more of the following are present: Vertebrates: Comely Shiner, Margined Madtom, Northern Hogsucker, River Chub, Shield Darter, Warmouth, Yellow Perch, Dusky Salamander, Long-Tailed Salamander. River chub, warmouth, yellow perch only in larger streams. In very small headwaters fish may be absent, but salamander species are present. Invertebrates: Ephemeroptera: *Habrophlebia; Epeorus; Ephemera; Leucrocuta; Habrophlebiodes,;Paraleptophlebia, Drunella* Plecoptera: *Sweltsa; Talloperla; Eccoptura; Pteronarcys* Trichoptera: *Wormaldia Diplectrona, Rhyacophila, Dolophilodes, Psilotreta; Goera; Lepidostoma* Diptera: *Dixa*, Prodiamesinae
Natural or native condition *Native structural, functional and taxonomic integrity is preserved; ecosystem function is preserved within the range of natural variability*	III *Intermediate Sensitive taxa* : Densities of Intermediate Sensitive taxa are as naturally occur: Vertebrates (examples): Fallfish, Rosyside Dace, Potomac Sculpin, Blue Ridge Sculpin, Common Shiner, Fantail Darter, Central Stoneroller. All sensitive vertebrates combined are well more than half of the vertebrate fauna in richness and abundance. Invertebrates (examples): Plecoptera: *Amphinemura, Acroneuria; Leuctra; Isoperla; Clioperla; Prostoia, Allocapnia,* Ephemeroptera: *Diphetor, Acentrella; Ephemerella, Ameletus; Serratella/Teloganopsis; Odonata: Cordulegaster; Lanthus* Trichoptera: *Neophylax; Rhyacophila; Pycnopsyche; Glossosoma* Coleoptera: *Oulimnius; Anchytarsus; Psephenus; Promoresia* Diptera: Diamesinae*; Hexatoma; Prosimulium;*
	IV *Taxa of Intermediate tolerance:* Densities of intermediate tolerant taxa are as naturally occur: Vertebrates (examples): Channel Catfish, Tessellated Darter, Pumpkinseed, Least Brook Lamprey Invertebrates (examples): Ephemeroptera: *Baetis; Stenonema; Caenis* Odonata: *Argia; Calopteryx; Boyeria* Trichoptera: *Chimarra, Cheumatopsyche, Hydropsyche, Polycentropus; Ironoquia* Coleoptera: *Helichus; Optioservus; Stenelmis;* Megaloptera: *Nigronia;* Diptera: *Chelifera, Clinocera;* Tanytarsini, *Tipula, Simulium;* Non-Insects: *Crangonyx;* Enchytraeidae;
	V *Tolerant taxa* : Occurrence and densities of tolerant taxa are at low density, as naturally occur: Vertebrates (examples): American Eel, Blacknose Dace, Creek Chub, Golden Shiner, Mummichog, White Sucker, Northern Two-Lined Salamander. Invertebrates (examples): Coleoptera: Most Hydrophilidae and Dytiscidae genera; Diptera: most Chironomini and Orthocladiinae*;* Tabanidae, Stratiomyiidae; Non-Insects: Isopoda, Physidae, Hirudinae*;* Tubificidae
	VI-i *Intolerant Non-native, intentionally introduced taxa* : Non native taxa such as Brown Trout or Rainbow Trout, are absent or, if they occur, their presence does not displace native trout or alter structure and function.
	VI-m *Intermediate Non-native taxa* : Do not occur. Vertebrates (examples): Smallmouth Bass, Black Crappie, Longear Sunfish, Golden Redhorse. Invertebrates: Asian clam *(Corbicula)*
	VI-m *Tolerant Non-native taxa* : Do not occur. Vertebrates (examples): Common Carp, Goldfish, Fathead Minnow, Green Sunfish, Largemouth Bass
	VII *Physiological condition of long-lived organisms:* Anomalies are absent or rare; any that occur are consistent with naturally occurring incidence and characteristics
	VIII *Ecosystem Function:* Rates and characteristics of life history *(e.g., reproduction, immigration, mortality, etc.)*, and materials exchange processes *(e.g., production, respiration, nutrient exchange, decomposition, etc.)* are comparable to that of "natural" systems; the system is predominantly heterotrophic, sustained by leaf litter inputs from intact riparian areas, with low algal biomass; P/R<1 (Photosynthesis: Respiration ratio)
	IX *Spatial and temporal extent of detrimental effects:* Not applicable- disturbance is limited to natural events such as storms, droughts, fire, earth-flows. A natural flow regime is maintained.
	X *Ecosystem connectance:* Depending on size of stream, migratory fish such as American eel or sea lamprey occur (absent in smallest headwaters). Depending on local geology, reach is highly connected with groundwater, its floodplain, and riparian zone, and other reaches in the basin. Many Piedmont streams are coolwater due to natural groundwater input. Allows for access to habitats and maintenance of seasonal cycles that are necessary for life history requirements, colonization sources and refugia for extreme events.

2 **Minimal changes in structure of the biotic community and minimal changes in ecosystem function** *Virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability*	***Whole assemblage and sample*** • Overall taxa richness and density is as naturally occurs (species names are not repeated – see description of BCG Level 1 for names) **I *Historically documented, sensitive, long-lived, regionally endemic taxa*** • Depending on size of stream, one or more of Attribute I fish are present. Brook trout as top predator **II *Highly Sensitive taxa*** • Richness of rare and/or specialist invertebrate taxa is low to moderate though densities may be low. • At least some taxa are present; **vertebrates** occur at densities higher than single accidental individual. **Invertebrates:** Several taxa present.(comprising nearly 1/5th of all taxa) **III *Intermediate Sensitive taxa*** • Richness and abundance of intermediate sensitive taxa is high. • **Vertebrates and Invertebrates**: All sensitive taxa (highly sensitive + intermediate sensitive): comprise half or more of all taxa and individuals **IV *Taxa of Intermediate tolerance*** • Present but generally comprise less than half of species and abundance **V *Tolerant taxa*** • Occurrence and densities of Tolerant taxa are as naturally occur. Typically present but a very small fraction of organisms. • Migratory fish species present. **VI-i *Intolerant Non-native, intentionally introduced taxa*** • Reproducing populations of brown trout or rainbow trout may be present indicating good water quality; cannot displace brook trout **VI-m, VI-t *Intermediate and Tolerant Non-native taxa*** • Do not occur. ***Physiological condition; Ecosystem Function; Spatial and temporal extent*** • Not addressed **X *Ecosystem connectance*** • Connectance on a local scale (floodplain, tributaries) remains good; dams and other flow obstructions downstream do not impede migration of eels and lamprey.

3	***Whole assemblage and sample*** • Overall taxa richness is as naturally occurs but density may be higher due to enrichment or other subsidy-stress effect. (species names are not repeated – see description of BCG Level 1 for names)
Evident changes in structure of the biotic community and minimal changes in ecosystem function *Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but <u>sensitive-ubiquitous</u> taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system*	I ***Historically documented, sensitive, long-lived, regionally endemic taxa*** • Typically absent II ***Highly Sensitive taxa*** • Highly sensitive vertebrates may be absent but 2-3 highly sensitive invertebrate taxa observed. III ***Intermediate Sensitive taxa*** • Richness and abundance of intermediate sensitive taxa is high. • **Vertebrates**: All sensitive taxa (highly sensitive + intermediate sensitive): comprise nearly half or more of all taxa and individuals; may be less than half in smaller streams (< 1.5 sq mi); **Invertebrates**: all sensitive taxa combined make up >50% of taxa and abundance. IV ***Taxa of Intermediate tolerance*** • Vertebrates: Present but makeup less than half of species and abundance ; • **Invertebrates**: overall increase in richness and elevated abundance but comprising <40% of taxa and <25% abundance V ***Tolerant taxa*** • Occurrence and densities of tolerant taxa higher than in Level 2; may be greater than half of community in smaller streams • Tolerant individuals less than half of all individuals in larger streams; **Invertebrates**: make up only 10% of richness and <25% of individuals. VI-i ***Intolerant Non-native, intentionally introduced taxa:*** May be absent VI-m ***Intermediate Non-native taxa:*** May occur VI-t ***Tolerant Non-native taxa*** • May occur at low densities • Tolerant nonnative individuals comprise small fraction of all vertebrates ***Physiological condition; Ecosystem Function; Spatial and temporal extent*:** Not addressed X ***Ecosystem connectance*** • Connectance on a local scale (floodplain, tributaries) remains good; eels and lamprey may be absent due to dams and other flow obstructions. Non-native sunfish (centrachidae) may occur due to ponds and dams.

	Whole assemblage and sample
4	• Overall taxa richness is slightly reduced, and density may be high. (species names are not repeated – see description of BCG Level 1 for names)
Moderate changes in structure of the biotic community and minimal changes in ecosystem function *Moderate changes in structure due to replacement of some Sensitive-ubiquitous taxa by more tolerant taxa, but reproducing populations of some Sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes*	I ***Historically documented, sensitive, long-lived, regionally endemic taxa:*** Absent II ***Highly Sensitive taxa*** • Typically absent but could occur in low numbers depending on proximity to cleaner tributaries III ***Intermediate Sensitive taxa*** • Richness and abundance of intermediate sensitive taxa is reduced, but at least some species remain at viable densities as functioning part of community. Coldwater invertebrate taxa are limited. • Vertebrates: Two or three sensitive taxa occur; at more than a small fraction of total individuals. Sensitive fish may be absent in very small headwaters (< 1 sq mi) if sensitive salamanders are present. Invertebrates: Several taxa possible but comprise less than 40% of richness and <30% abundance. IV ***Taxa of Intermediate tolerance*** • Present and may be diverse and abundant showing increases from Level 3. V ***Tolerant taxa*** • Occurrence and densities of tolerant taxa higher; may be accompanied by high dominance of one or two species VI-i ***Intolerant Non-native, intentionally introduced taxa*** • Typically absent VI-m ***Intermediate Non-native taxa*** • May occur VI-t ***Tolerant Non-native taxa*** • May occur at higher densities; may be dominant ***Physiological condition; Ecosystem Function; Spatial and temporal extent:*** Not addressed X ***Ecosystem connectance*** Connectance disrupted; eels and lamprey typically absent due to dams and other flow obstructions. Non-native sunfish (centrachidae) occur due to ponds and dams. Filling of interstitial spaces obstructs access to hyporheic zone for early instar mayfly/stonefly nymphs, eliminating nursery areas and *refugia* for storm-events and low flows. Adult stoneflies from upstream reaches continue to oviposit but reproductive success is limited; stonefly/mayfly nymphs continue to colonize by drift, with limited success.

5

Major changes in *structure* of the biotic community and moderate changes in *ecosystem function*

Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased build-up or export of unused materials

Whole Assemblage And Sample

- Overall Taxa richness is reduced, but density may be high. (species names are not repeated – see description of BCG level 1 for names)

I ***Historically Documented, Sensitive, Long-Lived, Regionally Endemic Taxa***

- Absent

II ***Highly Sensitive Taxa***

- Absent

III ***Intermediate Sensitive Taxa***

- Richness and abundance of intermediate sensitive taxa is greatly reduced, may be absent.

IV ***Taxa Of Intermediate Tolerance***

- Present and may be diverse and abundant

V ***Tolerant Taxa***

- Occurrence and densities of tolerant taxa high; accompanied by high dominance of one or two species

VI-I ***Intolerant Non-Native, Intentionally Introduced Taxa*** : Typically absent

VI-M ***Intermediate Non-Native Taxa:*** May occur

VI-T ***Tolerant Non-Native Taxa***

- Occurrence and densities of tolerant taxa high; accompanied by high dominance of one or two species

Physiological Condition; Ecosystem Function; Spatial And Temporal Extent

- Not Addressed

X ***Ecosystem Connectance***

- Connectance disrupted; eels and lamprey typically absent due to dams and other flow obstructions. non-native sunfish (Centrachidae) occur due to ponds and dams. Filling of interstitial spaces obstructs access to hyporheic zone for early instar mayfly/stonefly nymphs, eliminating nursery areas and *refugia* for storm-events and low flows. Adult stoneflies from upstream reaches may continue to oviposit but reproductive success is limited; mayfly/stonefly nymphs may colonize by drift unless headwater tributaries are impacted.

<table>
<tr><td>6

Severe changes in structure of the biotic community and major loss of ecosystem function

Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered</td>
<td>Whole Assemblage And Sample
• Overall Taxa richness is greatly reduced, but density may be high (extreme enrichment), or very low (indicating toxicity). (species names are not repeated – see description of BCG Level 1 for names)

I Historically Documented, Sensitive, Long-Lived, Regionally Endemic Taxa
• Absent

II Highly Sensitive Taxa
• Absent

III Intermediate Sensitive Taxa
• Typically absent

IV Taxa Of Intermediate Tolerance
• May be present but typically reduced diverse and abundance

V Tolerant Taxa
• High dominance of one or two species

VI-I Intolerant Non-Native, Intentionally Introduced Taxa
• Absent

VI-M Intermediate Non-Native Taxa
• May be absent

VI-T Tolerant Non-Native Taxa
• May have high dominance of one or two species (e.g., Fathead Minnow, Common Carp)

Physiological Condition; Ecosystem Function; Spatial And Temporal Extent
• Not Addressed

X Ecosystem Connectance
Connectance disrupted; eels and lamprey typically absent due to dams and other flow obstructions. non-native tolerant fish occur. Sources of colonists from headwater tributaries are missing with increased burial and piping of headwaters.</td></tr>
</table>

Conclusion

The results of this pilot showed a remarkable level of agreement among the experts (Montgomery County, MDE, MDNR, USEPA, and University of Maryland) and across assemblages (benthic macroinvertebrates, fish and salamander). Further refinement and analysis are planned this spring and summer, including evaluation of independent data sets but the preliminary findings show that:

1) The individual expert judgments of the biological condition of the Ten Mile Creek sites ranged between high to fair quality (BCG levels 2- to level 4). The highest quality Ten Mile Creek site was the King Spring Tributary where the primary headwater stream supported cold and cool water sensitive, native benthic macroinvertebrate taxa. The experts predicted that these sites were excellent candidates for protection. A cursory evaluation of watershed condition indicate the area immediate to these streams have no or low road density and impervious surface. However, the fish community is potentially impacted by influences from novel, non-native taxa swimming upstream from the reservoir in Ten Mile Creek.

2) Three of the sites were sampled before and after land use disturbance and changes in the assemblages were consistently identified by the experts and results in lower BCG level assignments. For instance, Samp006 (Right Fork) macroinvertebrates changed from a Level 2+ stream to a 4-between 1998 and 2012; some highly sensitive, cool and coldwater invertebrate taxa (Diplectrona, Dolophilodes, Eccoptura) and some intermediate sensitive taxa (e.g., Ephemerella)were eradicated following urbanization. All three sites came from County Special Protection Areas (SPA) – one in the Upper Paint Branch, one in the Piney Branch and one in the Clarksburg Master Plan. The land use disturbance resulted from the conversion of rolling piedmont fields and forests to residential development of different levels of imperviousness.

3) High quality Northern Piedmont sites such as Ten Mile Creek and Sopers Branch showed potential for supporting native brook trout populations. These streams may be candidates for a use upgrade from class 1 to class 3. MDE and MDNR experts participating in the expert panel offered to work with Montgomery County to further evaluate this possibility.

4) The information from the three different assemblages (*benthic macroinvertebrates, fish, salamanders*) were complementary and provided strong evidence for identifying high quality conditions and detecting early response to stress in sensitive, threatened streams. In particular, the presence of sufficient numbers of sensitive, cold and cool water benthic invertebrates and sensitive salamander are robust indicators of high quality conditions, including sites that could support the return of native brook trout. Additionally, certain fish taxa such as eels, herring, or sea lamprey are indicative of streams that are not disconnected from the Mainstem River and the Chesapeake Bay. These fish species migrate from coastal waters up through the rivers and into the streams.

5) Because of the high quality nature of Ten Mile Creek headwaters (e.g., Kings Spring Tributary and similar 1st order streams); coldwater indicators and the potential for Brook Trout re-introduction in Ten Mile Creek; and the documented decline in biological quality from "before and after" studies as in the Clarksburg Tributary example, caution should be applied for planned urban developments within upland and headwaters in order to protect these high quality, sensitive streams and the watershed.

6) The experts discussed the use of the Northern Piedmont BCG as a framework for communicating to the public and their officials detailed information on the condition of the aquatic biota and potential for restoration and for protection; predicted biological gains from management actions; and progress once actions taken. This framework will help develop a BCG using quantitatively robust data from the Northern Piedmont of Maryland that could materially assist local efforts to describe risk in different development and land use options as well as restoration opportunities. Based on a very preliminary analysis of the relationship between the BCG level site assignments by the experts and the site's ibi scores, the BCG analysis provided additional precision in detecting early or more subtle shifts in the biota indicative of either degradation or improvements depending on the direction of change. This result indicates the potential for using a BCG to supplement the existing IBIs and enhance the county's biological assessment approach to detect high quality conditions and track progress in restoration.

7) Numeric decision rules can be developed and the narrative model quantified with further refinement of the narrative BCG (e.g., analysis of a larger data set, continued expert solicitation, and independent peer review). A numeric BCG can then be used to refine and improve existing biological indices or become basis for new biological indices.

APPENDIX A

SELECTED CASE EXAMPLES FROM:

A PRIMER ON USING BIOLOGICAL ASSESSMENTS TO SUPPORT WATER QUALITY MANAGEMENT

EPA 810-R-11-01

These case studies show use of a biological condition gradient framework to support state water quality management programs.

3.1 Protecting Water Quality Improvements and High Quality Conditions in Maine

Abstract

Maine has used biological, habitat, and other ecological information to designate aquatic life uses that reflect the highest achievable conditions of its waterbodies and has used antidegradation policy to maintain and protect high existing conditions. Maine uses a Biological Condition Gradient to designate levels of protection for its waterbodies (e.g., designated aquatic life uses) and to assign numeric biological criteria to protect those uses. Maine describes the system as a *tiered use classification*. For Maine, tiered aquatic life uses highlight the relationship between biology, water quality, and watershed condition in determining the need for waterbody protection to maintain existing high quality conditions or the potential for water quality improvement to attain water quality standards. Maine's integrated, data-driven approach has resulted in documented improvement in water quality throughout the state, including upgrades of designated uses of more than 1,300 stream miles, from Class C to Class B, and from Class B to Class A or AA waters (Outstanding National Resource Waters).

In 1983 the Maine Department of Environmental Protection (ME DEP) initiated a statewide biological monitoring and assessment program and revised water quality standards (WQS) by 1986 to recognize high levels of water quality condition. Maine established four classes for freshwater rivers and streams (see Table 3-1). All four classes meet or exceed the Clean Water Act (CWA) section 101(a)(2) goal for aquatic life protection. Every waterbody is assigned to one of four tiers by considering its existing biological condition, its highest achievable condition on the basis of biological potential, aquatic habitat, watershed condition, levels of dissolved oxygen, and numbers of bacteria (Table 3-1). Agency biologists developed a linear discriminant model to measure the biological attainment of each class, establish numeric biological criteria, and assign corresponding antidegradation tiers for purposes of statewide planning (see Table 3-1, column 6). Part of Maine's antidegradation policy requires that where any actual measured water quality criterion exceeds that of a higher class, that quality must be maintained and protected [Maine Revised Statutes Title 38, §464.4(F)]. In effect, by having multiple levels of aquatic life use standards in law, Maine has established a means of improving water quality in incremental steps, and of using antidegradation reviews and reclassification upgrades to maintain and protect water quality and aquatic life conditions that exceed existing or designated aquatic life uses.

The following case study offers an example of how Maine has used tiered use classifications and antidegradation policy cooperatively in its water quality management program. In conjunction with habitat and other chemical and physical parameters, Maine assigns waters to designated use classes (AA, A, B, or C; Table 3-1) on the basis of the *potential* for water quality improvement. In the 1980s, monitoring on the Piscataquis River near the towns of Guilford and Sangerville found aquatic life conditions insufficient to meet even the minimum Class C conditions at which the river was classified. The segment of the river in the Guilford-Sangerville area had a history of poor water quality, including recurrent fish kills from poorly treated industrial and municipal wastes. However, the state determined that this segment of the river could attain at least Class C. The state determined that sewage treatment plant and industrial discharges were the only significant source of stressors to the river, with very good quality upstream conditions and good salmonid production elsewhere. Additionally, the river's habitat structure and hydrologic regime were very good.

Table 3-1. Criteria for Maine River and stream classifications and relationship to antidegradation policy.

Class	Dissolved oxygen criteria	Bacteria criteria	Habitat narrative criteria	Aquatic life narrative criteria*** and management limitations/restrictions	Corresponding federal antidegradation policy tiers
AA	As naturally occurs	As naturally occurs	Free-flowing and natural	As naturally occurs**; no direct discharge of pollutants; no dams or other flow obstructions.	3 (Outstanding National Resource Water [ONRW])
A	7 ppm; 75% saturation	As naturally occurs	Natural**	Discharges permitted only if the discharged effluent is of equal to or better quality than the existing quality of the receiving water; before issuing a discharge permit the Department shall require the applicant to objectively demonstrate to the department's satisfaction that the discharge is necessary and that there are no reasonable alternatives available. Discharges into waters of this class licensed before 1/1/1986 are allowed to continue only until practical alternatives exist.	2 1/2
B	7 ppm; 75% saturation	64/100 mg (g.m.) or 236/100 ml (inst.)*	Unimpaired**	Discharges shall not cause adverse impact to aquatic life** in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous** to the receiving water without detrimental changes to the resident biological community.**	2 to 2 1/2
C	5 ppm; 60% saturation; and 6.5 ppm (monthly avg.) when temperature is </= 24 °C	125/100 mg (g.m.) or 236/100 (inst.)*	Habitat for fish and other aquatic life	Discharges may cause some changes to aquatic life**, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous** to the receiving waters and maintain the structure** and function** of the resident biological community. **	1 to 2

Source: Maine DEP (modified).
http://www.maine.gov/dep/blwq/docmonitoring/classification/reclass/appa.htm.

Notes:

* g.m. = geometric mean; inst. = instantaneous level.

** Terms are defined by statute (Maine Revised Statutes Title 38, §466).

*** Numeric biological criteria in Maine regulation Chapter 579, Classification Attainment Evaluation Using Biological Criteria for Rivers and Streams.

Four years after issuance of new National Pollutant Discharge Elimination System (NPDES) permits requiring better industrial pretreatment and improved wastewater treatment at the Guilford-Sangerville treatment facility, follow-up monitoring found water quality improvements that exceeded Class C and attained Class B aquatic life conditions. The achievement of higher water quality conditions was preserved through a classification upgrade process (supported by the industry and the two towns). The river was upgraded to Class B and now attains those higher aquatic life use goals. The redesignation process requires the state legislature to enact a statutory change of a waterbody's classification and can take considerable time to complete. However, during the reclassification process the improved water quality conditions existing in the Piscataquis River were protected through implementation of the state's Tier II antidegradation policy. The value secured by maintaining the higher quality condition was demonstrated in 2009 when the Piscataquis River was designated as critical habitat for the restoration of the endangered Atlantic salmon.

The management actions based on documented improvements in the biological condition in this example demonstrate the complementary application of the state's tiered aquatic life use classification and the Tier 2 and 2½ antidegradation policy. Using that approach, water quality upgrades from Class C to B and from B to A or AA have been repeated in many parts of the state, and subsequently maintained and protected. Overall, Maine has redesignated more than 1,300 miles of streams to a higher class on the basis of biological information (e.g., biological improvements due to point source controls, nonpoint source practices, dam operational modifications or removal) and societal values (e.g., water quality and habitat protection for wild trout populations; critical species protection, especially Atlantic salmon habitat and tribal petitions).

3.3 Protection of Antidegradation Tier II Waters in Maryland

Abstract

Maryland is identifying high-quality waters for antidegradation purposes on a waterbody-by-waterbody basis. Maryland has designated Tier II waters on the basis of two indices of biotic integrity—fish and benthic invertebrates—and provides additional protection so that those waters are not degraded. New or increased point source dischargers and local sewer planning activities that have the potential to affect Tier II waters are required to examine alternatives to eliminate or reduce discharges or impacts. The state has developed requirements that must be met for projects that do not implement a no-discharge alternative. To help local planners to determine whether a planned activity has the potential to affect a Tier II water, the state has developed geographic information system shapefiles that identify such waters. Those files are provided to local jurisdictions to improve their knowledge of where Tier II waters occur. Biological assessments, in conjunction with chemical and physical assessments, are then conducted to determine the status of those waters and detect trends in condition.

In its state water quality standards (WQS), Maryland adopted an antidegradation policy for protecting all waters for existing and designated uses. High-quality (Tier II) waters receive additional attention and regulatory protections. Identification of Tier II waters, in this case streams, is based on a waterbody-by-waterbody approach using biological survey data, from which two indices of biotic integrity (IBIs) are developed—one for benthic invertebrates and one for fish. Those with both scores above 4 are designated Tier II waters. The state has identified more than 230 high-quality water segments. To protect downstream high-quality waters, a watershed approach to protection is applied. Tier II waters must be protected so that water quality does not degrade to minimum standards, and that requirement has implications for potential discharges and local planning activities.

Application of Tier II Protection

The Maryland Department of the Environment (MDE) requires that applicants for amendments to county plans (i.e., water and sewer plans) or permits for new or expanding point source discharges evaluate alternatives to eliminate or reduce discharges or impacts [COMAR 26.08.02.04-1(B)]. Applicants for permits must consider whether the receiving waterbody is Tier II (or whether a Tier II determination is pending); MDE reviews proposed amendments to county plans discharging to Tier II waters. In both cases, discharges to Tier II waters require a Tier II review [2.26.08.02.04-1(F)].

MDE has developed a cooperative approach to protecting Tier II waters. Monitoring and WQS programs work with the National Pollutant Discharge Elimination System (NPDES) permitting program to help screen for potential effects from new or expanded discharges and to develop permit conditions to minimize those effects and maintain existing high-quality waters. Outreach materials are available to educate county planners about Tier II waters, and geographic information system (GIS) shapefiles that planners can use to help locate Tier II waters within their jurisdictions have been developed.[1] That information provides Maryland county planners a way to determine early on whether their projects could affect Tier II waters.

[1] More information about GIS is at http://www.gis.com/content/what-gis.

A list of recommendations for land-disturbing projects that are not able to implement a no-discharge alternative provides the following initial guidance:

1. Implementation of environmental site design (also known as low-impact development)—Design elements and practices must be approved for Tier II waters with opportunity provided for exploration of appropriate alternatives and justification for structural elements in the proposed designs.
2. Expanded riparian buffers—Buffers must be at a minimum of 100 feet; wider buffers may be required depending on slope and soil type.
3. Biological, chemical, and flow monitoring in the Tier II watershed—Applicants may be required to conduct biological assessments in conjunction with chemical, physical, and flow assessments to help determine the remaining assimilative capacity and cumulative impacts of current and future development. Depending on project specifics, additional monitoring may be required, such as the completion of a hydrogeologic study for a major mining project or additional pH monitoring because of impacts associated with instream grout applications seen in many common transportation projects.
4. Additional practices—Depending on the potential for project-specific effects on water quality, applicants may be required to implement other practices, such as enhanced sediment and erosion control practices or implementation of more environmentally protective alternatives.

If those general requirements cannot be implemented, applicants must submit a detailed hydrologic study and alternatives analysis to demonstrate that the assimilative capacity of a waterbody will be maintained. The assimilative capacity of a waterbody is typically site-specific and determined through studies of the waterbody. In terms of WQS, assimilative capacity is a measure of the capacity of a receiving water to assimilate additional pollutant(s) but still meet the applicable water quality criteria and designated uses.

3.4 Using Complementary Methods to Describe and Assess Biological Condition of Streams in Pennsylvania

Abstract

The Pennsylvania Department of Environmental Protection (PA DEP) has developed a new benthic macroinvertebrate index of biotic integrity (IBI) to assess the health of wadeable, freestone (e.g., high gradient, soft water) streams. Additionally, PA DEP calibrated a benthic macroinvertebrate Biological Condition Gradient (BCG) and is exploring using the BCG to more precisely describe biological characteristics in Pennsylvania streams. Potentially, the BCG can be used in conjunction with the IBI to identify aquatic life impairments and to describe the biological characteristics of waters assigned special protection. PA DEP is also exploring using a discriminant analysis model with additional taxonomic, habitat, and landscape parameters to describe exceptional value waters.

Describing Waters along a Gradient of Condition

Pennsylvania Department of Environmental Protection (PA DEP) has developed a new benthic macroinvertebrate index of biotic integrity (IBI) for the wadeable, freestone (high-gradient, soft-water) streams in Pennsylvania using the reference condition approach (PA DEP 2009). PA DEP has alternative assessment methods in place for other stream types (i.e., low-gradient pool-gliders, karst [limestone]-dominated). The IBI provides an integrated measure of the overall condition of a benthic macroinvertebrate community by combining multiple metrics into a single index value. PA DEP uses the IBI to assess attainment of aquatic life uses.

> A **metric** is a measurable aspect of a biological community that responds in a consistent, predictable manner to increasing anthropogenic stress. Examples of metrics include **taxa richness**, which is a measure of the number of different kinds of organisms (taxa) in a sample collection, and **% dominance**, which is a measure of which species compose the majority of organisms present in a sample collection.
>
> To gain a more comprehensive view of an aquatic community, multiple types of metrics are combined into a **biological, or biotic, index**. The typical biological index may include information from 7 to 12 different metrics. The metric values are typically scored on a unitless scale of 0 to 100 and averaged to obtain a single value.

Additionally, PA DEP is exploring use of a Biological Condition Gradient (BCG) to describe the biological characteristics of freestone streams along a gradient of condition. PA DEP conducted a series of three expert workshops in 2006, 2007, and 2008 to calibrate a BCG along a gradient from minimally to heavily stressed conditions (PA DEP 2009). The BCG is a narrative model based on measurable attributes, or characteristics, of aquatic biological communities expected in natural conditions (e.g., presence of native taxa, some pollution tolerant taxa present but typically not dominant, absence of invasive species). Additionally, the BCG model includes attributes that describe interactions among biotic communities (e.g., food web dynamics), the spatial and temporal extent of stress, and the presence of naturally occurring habitats and landscape condition (for more information, see Tool # 2, *The Biological Condition Gradient*). To date, states and tribes that have applied the BCG have used the BCG attributes that describe the taxonomic composition of the resident aquatic biota and, where available, information on fish condition, for example lesions and abnormalities (BCG attributes I–VII) (see Table 2-2). Some states are exploring the application of additional attributes on food web dynamics, extent of stress, and landscape condition (BCG attributes VIII–X). These efforts are providing valuable information that will aid the U.S. Environmental Protection Agency (EPA) in further refining the BCG.

To develop the BCG for its streams, biologists from PA DEP, in conjunction with external taxonomic experts and scientists, e.g., the Delaware River Basin Commission, Western Pennsylvania Conservancy, and EPA, used the BCG attributes that characterize specific changes in community taxonomic composition (PA DEP 2009). For example, in the highest tiers of the BCG, locally endemic, native, and sensitive taxa are well represented (attributes I and II) and the relative abundances of pollution-tolerant organisms (attribute V) are typically lower. With increasing stress, more pollution-tolerant species may be found with concurrent loss of pollution-sensitive species (attribute VI). At the beginning of the expert workshops, the biologists first assigned or adjusted BCG attributes to each macroinvertebrate taxon (e.g., pollutant-sensitive or tolerant) and then reviewed taxa lists from samples representing minimally disturbed to severely disturbed site conditions (Figure 3-2). The evaluated samples included sites judged as either reference quality (e.g., at or close to minimally disturbed conditions) or heavily stressed based on specific selection criteria (PA DEP 2009). To further test the robustness of the BCG process, additional sites that were not part of the reference or heavily stressed sample groups were evaluated. Those sites represented a range of site conditions, including moderately to heavily stressed site conditions (non-reference and moderately stressed; see Figure 3-2). Using the BCG tier descriptions of predicted changes in the attributes as a guide, they assigned each site to one of the six BCG tiers.

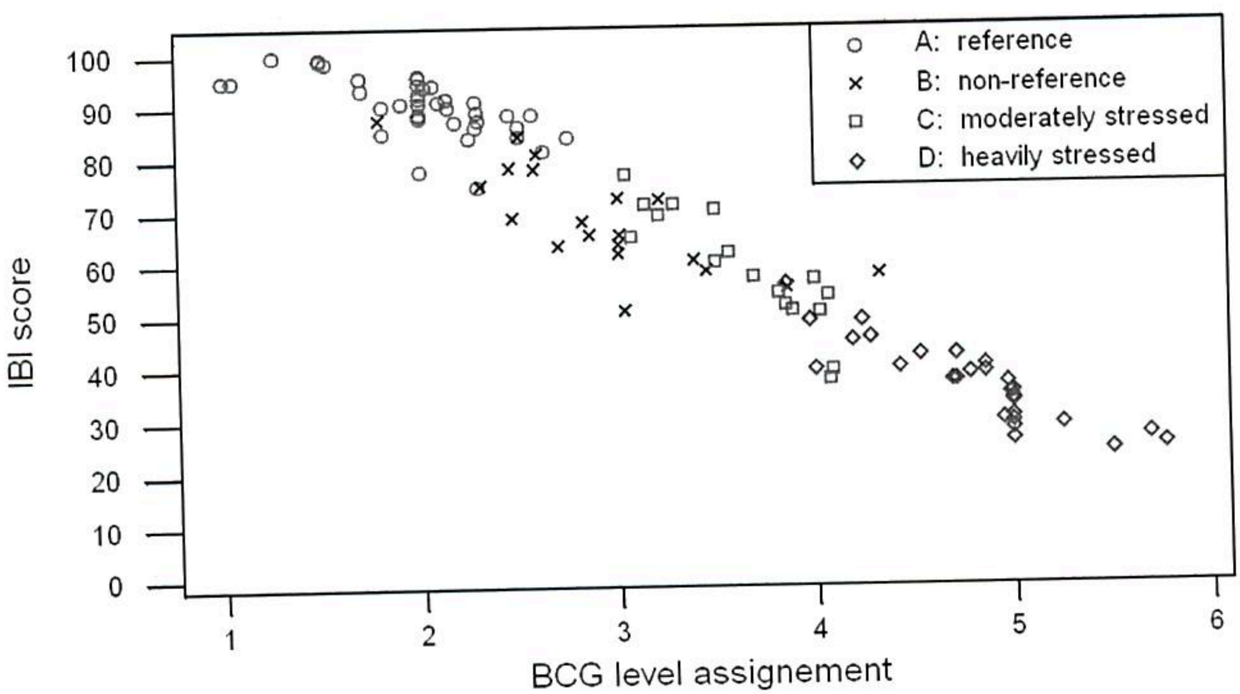


Figure 3-2. Comparison of calibrated BCG tier assignments (mean value) and IBI scores for freestone streams representing range of conditions from minimal to severely stressed.

For all the evaluated samples, PA DEP biologists analyzed the relationship between a sample's BCG tier assignment with its corresponding IBI score (PA DEP 2009). A strong correlation existed between the calibrated BCG tier assignments and the IBI scores (Figure 3-2). Based on these results, PA DEP is evaluating using the BCG to describe the biological characteristics of streams along a gradient of condition; for example, the reference sites clustered at IBI scores near 80 and above. Based on taxonomic information and without knowledge of the IBI scores, the experts assigned these sites to BCG tiers 1.5 to 2.5. BCG tier 2 represents close to natural conditions (e.g., minimal changes in structure and function relative to natural, or pristine, conditions; supports reproducing populations of native species of fish and benthic macroinvertebrates). This information can meaningfully convey to the public the biological characteristics of waters in the context of the Clean Water Act and the goal to protect aquatic life. Using both the IBI and BCG, PA DEP might be able to develop a cost-effective, publicly transparent approach to routinely monitor and assess the condition of its freestone streams and to help identify potential high-quality (HQ) or exceptional value (EV) streams.

Describing Exceptional Value Waters

Pennsylvania's regulations define waters of EV that are of unique ecological or geological significance. EV streams are given the highest level of protection and constitute a valuable subset of Pennsylvania's aquatic resources. To support protection of these waters, PA DEP is considering the use of a discriminant analysis model to evaluate the relationship between condition of the watershed, a stream, and its aquatic biota (e.g., the connection of riparian areas with a stream and the floodplain or the spatial extent of stressors and their sources in the watershed). PA DEP is evaluating the use of a discriminant model that incorporates measures of land use and physical habitat along with IBI scores and indicator taxa richness to make distinctions between EV and HQ waters. The abiotic measures PA DEP is using address habitat fragmentation and spatial and temporal extent of stress and are comparable to the national BCG model attributes IX (extent of stress) and X (ecosystem connectance). The results of this effort could potentially support decisions on where to target resources for sustainable, cost-effective protection of EV waters and healthy watersheds. Through this work, PA DEP is providing EPA valuable feedback on the technical development and potential program application for BCG attributes IX and X.

Potential Application to Support Protection of Waters of Highest Quality

PA DEP is exploring new approaches to help identify streams that are of the highest quality and might require special protection. For example, a stream might be found to meet the expected biological condition of an HQ or EV water based on its IBI score and BCG tier assignment. This information could be used to support further study to determine whether its designation should be as an HQ water or if it meets the additional criteria for designation as an EV water. When biological information is presented in context of a BCG framework, it is easier for the public to understand the status of the aquatic resources, including waters that are in excellent condition and require additional protection.

3.5 Use of Biological Assessments to Support Use Attainability Analysis in Ohio

Abstract

Ohio uses biological assessment information in conjunction with physical habitat assessments to strengthen use attainability analyses (UAAs) in the state. The technical and programmatic underpinnings for Ohio's use attainability determinations is the state's aquatic life use classification approach, which is based on the relationship between biology, habitat, and the potential for water quality improvement. Ohio's biological monitoring and assessment program provides timely, statewide information on the status of waterbodies and the data to support a UAA if needed, including when biological conditions improve and an upgrade of a designated use is warranted. Typically, in situations where the habitat needed to meet aquatic life uses is present, Ohio has taken management actions to address water quality issues and restore impairments.

In 1990 Ohio used biological assessment information to specify levels of biological condition for specific streams and rivers based on ecoregional reference sites. As a result, the state refined definitions of some aquatic life uses, adopted new ones, and assigned biological criteria to key uses to support a tiered approach to water quality management within the Ohio water quality standards (Table 3-3).

Table 3-3. Summary of Ohio's beneficial use designations for the protection of aquatic life in streams.

Beneficial use designation	Key attributes
Coldwater habitat (CWH)	Native cold water or cool water species; put and take trout stocking.
Exceptional warmwater habitat (EWH)	Unique, unusual, and highly diverse assemblage of fish and invertebrates.
Seasonal salmonid habitat (SSH)	Supports lake run steelhead trout fisheries.
Warmwater habitat (WWH)	Typical assemblages of fish and invertebrates, similar to least impacted reference conditions.
Limited warmwater habitat (LWH)	Temporary designations based on 1978 WQS. Predate Ohio tiered aquatic life use classification and were not subjected to UAA; being phased out as UAA are conducted for each LWH waterbody or segment. Most of the LWH waterbodies or segments have been redesignated as WWH or higher with the exception of some mine-drainage-affected segments that were designated LRW.
Modified warmwater habitat (MWH)	More tolerant assemblages of fish and macroinvertebrates are present relative to a WWH assemblage, but otherwise generally similar species to WWH present; irretrievable modifications of habitat preclude complete recovery to least impacted reference condition.
Limited resource water (LRW)	Fish and macroinvertebrates severely limited by physical habitat or other irretrievable condition; minimum protection afforded by the CWA.

Source: Ohio EPA, April 2004. http://www.epa.ohio.gov/portals/35/wqs/designation_summary.pdf.

When designating aquatic life uses, the quality of habitat is a major factor in a use attainability analysis (UAA) process to determine the potential for restoration and expected biological condition for streams and rivers in Ohio. If sufficient good habitat attributes are not present, such as higher quality substrates and sufficient instream cover, a determination about restorability is made. If habitat is sufficient or could be restored, it is assumed that any observed biological impairments are due to the effects of other stressors (e.g., metals, nutrients) that could be remediated through readily available water quality management options (e.g., permit conditions and/or best management practices [BMPs]) and the biological assemblage restored. The aquatic life use classifications are based on ecological conditions, and in 1990 biological criteria were developed to protect each use. Ohio's biological criteria include two indices based on stream fish assemblages (Index of Biological Integrity [IBI] and Modified Index of Well-Being [MIwb]) and one index based on stream macroinvertebrate assemblages (Invertebrate Community Index [ICI]). The biological criteria were developed based on regional reference conditions and are stratified by each of the state's five level 3 ecoregions and three site types (headwater, wadeable, and boatable sites).

Using these aquatic life use classifications, Ohio has been able to determine attainable levels of condition for streams and rivers. For example, in the mid-1980s biological surveys of Hurford Run, a small stream located in an urban/industrial area of Canton, Ohio, showed that the stream was severely impaired by toxic chemical pollutants and that some sites had no fish at all. Hurford Run is channelized for nearly its entire length. Because of the severity of the biological impairment, a UAA was conducted to determine if the warmwater habitat (WWH) aquatic life use was attainable and, if not, to determine the most appropriate designated use for the stream. Based on biological and habitat assessments, the most appropriate aquatic life uses for the different segments of Hurford Run could be determined. For example, very poor habitat quality from historical channelization in the *upper reach of Hurford Run* and the associated hydrological modifications (e.g., ephemeral flows) resulted in a limited warmwater habitat (LWH) designation for this upper reach.

The *middle reach of Hurford Run* has been subject to extensive, maintained channel modifications that also resulted in degraded habitat features, though water is always present. Channel maintenance practices resulting in poor-quality substrates, poorly developed pools and riffles, and a lack of instream cover preclude biological recovery to assemblages consistent with the WWH use, which indicated that the middle reach should be designated a modified warmwater habitat (MWH), reflecting the attainable biological potential for a channel-modified stream determined by scientific studies. The *lower reach of Hurford Run* was previously relocated and channelized, but over time the reach has naturally recovered sufficient good-quality habitat attributes, such as coarse substrates and better developed riffle and pool features associated with the WWH use for this ecoregion. Biological assessments confirmed the presence of aquatic assemblages typical of WWH. Based on this information, this segment was designated as WWH. The designated aquatic life uses reflect the current best possible condition in each segment of Hurford Run and provide a basis for management actions to ensure that the associated criteria are met and the use is protected. Numeric biological criteria have been established for key designated aquatic life uses, and a segment is listed on the 303(d) list if it is in nonattainment of the biological criteria. Additionally, the different segments are routinely monitored by the state and the condition reevaluated on a regular basis. If there is any information indicating that a higher use is being attained or could be attained, that water is considered for redesignation to the higher use.

Ohio has also used biological assessment data to refine its water quality criteria in some cases. For instance, when Ohio's aquatic life use classifications were established in 1978, Ohio established dissolved oxygen criteria to protect each designated use. Initially, a dissolved oxygen criterion of 6 mg/L as a minimum was established for exceptional warmwater habitat (EWH) waters to protect highly sensitive species supported by this use. However, analyses of ambient biological and chemical data suggested that the 6 mg/L minimum criterion was over-protective for EWH waters. Data showed a relationship between stressors and biological measures, with dissolved oxygen concentrations less than 5.0 mg/L being associated with IBI scores not in attainment of EWH biological criteria. And, in general, data showed that with dissolved oxygen greater than 5.0 mg/L, IBI scores are much more likely to attain EWH. These results were used to justify refining the EWH criteria to the current 6 mg/L average, 5 mg/L minimum (Ohio EPA 1996). The criterion revision also supported the redesignation of some rivers and streams from WWH to EWH.

APPENDIX B

NORTHERN PIEDMONT REGION BIOLOGICAL CONDITION GRADIENT

Currently a separate file 4/2/13

APPENDIX C

Expert Solicitation Workshop: List of Experts, Data Spread Sheets

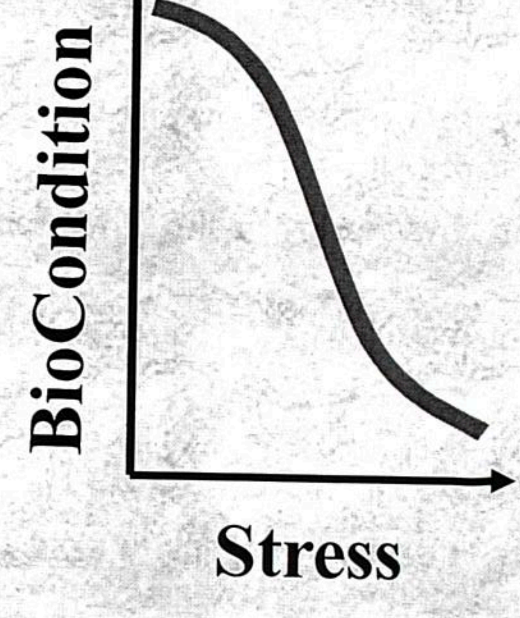
currently a separate file 4/2/13

What is the Biological Condition Gradient?

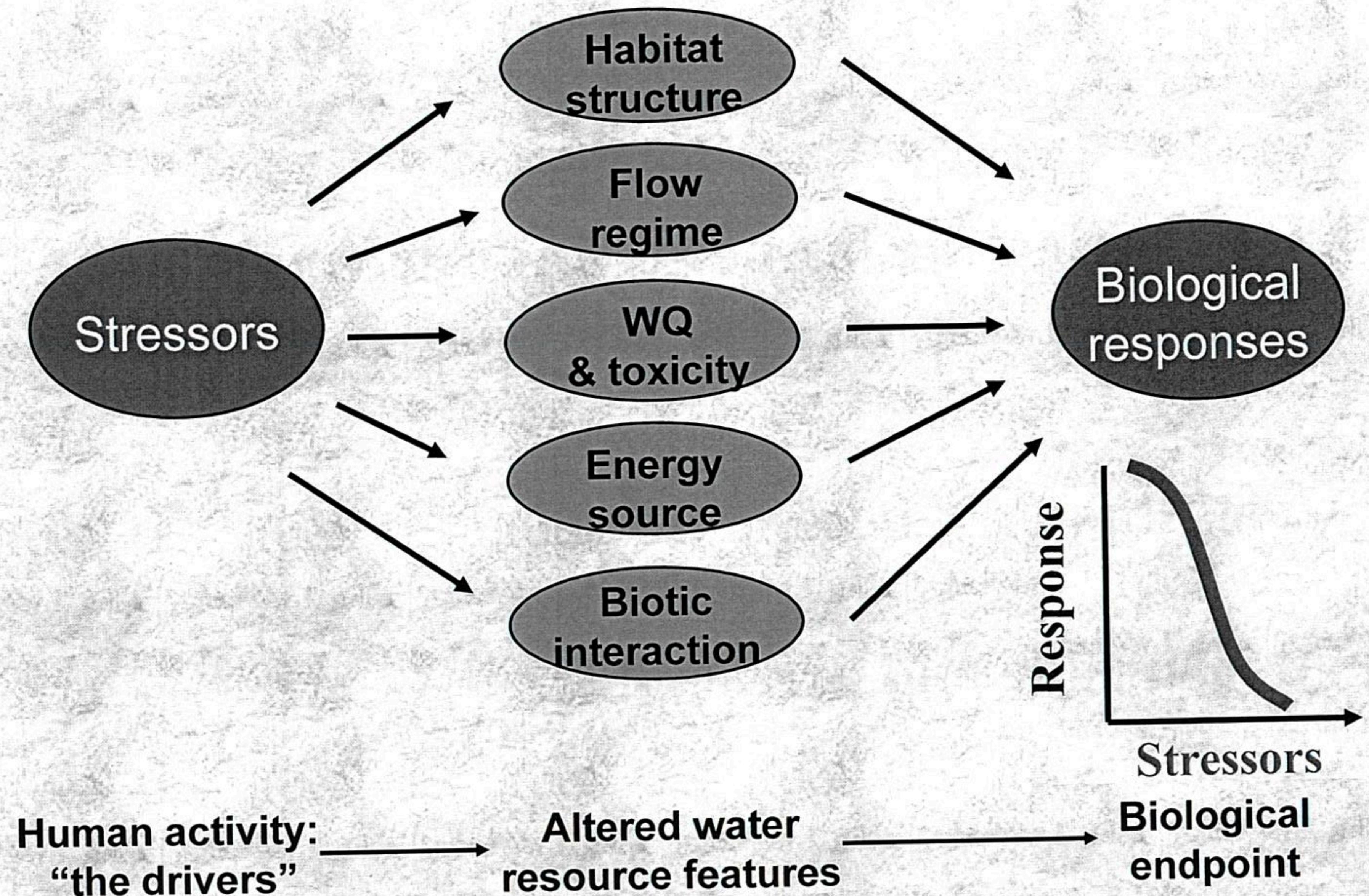
It is a scientific framework for determining biological response to anthropogenic stress.

Longstanding, accepted science

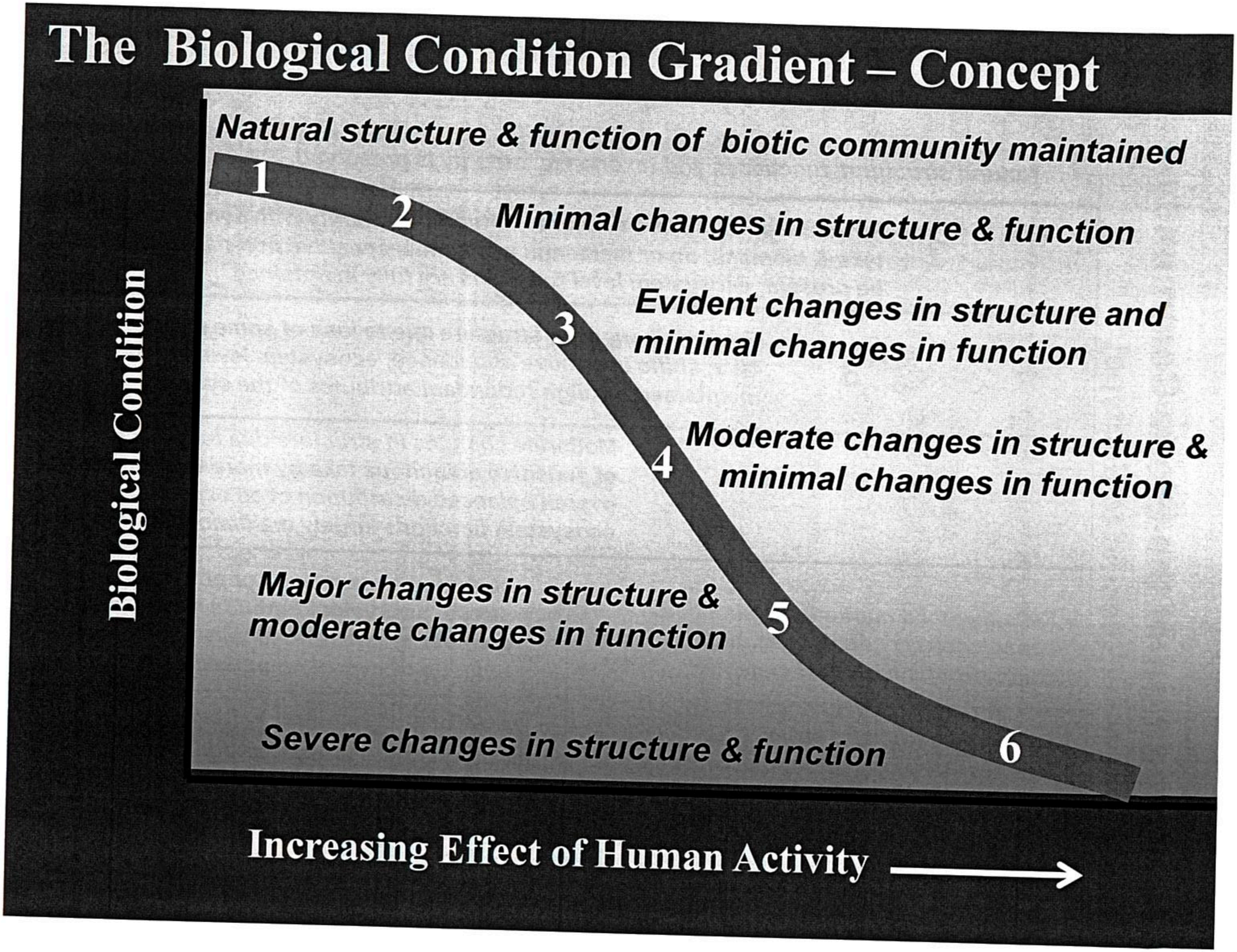
Measurable and predictable.



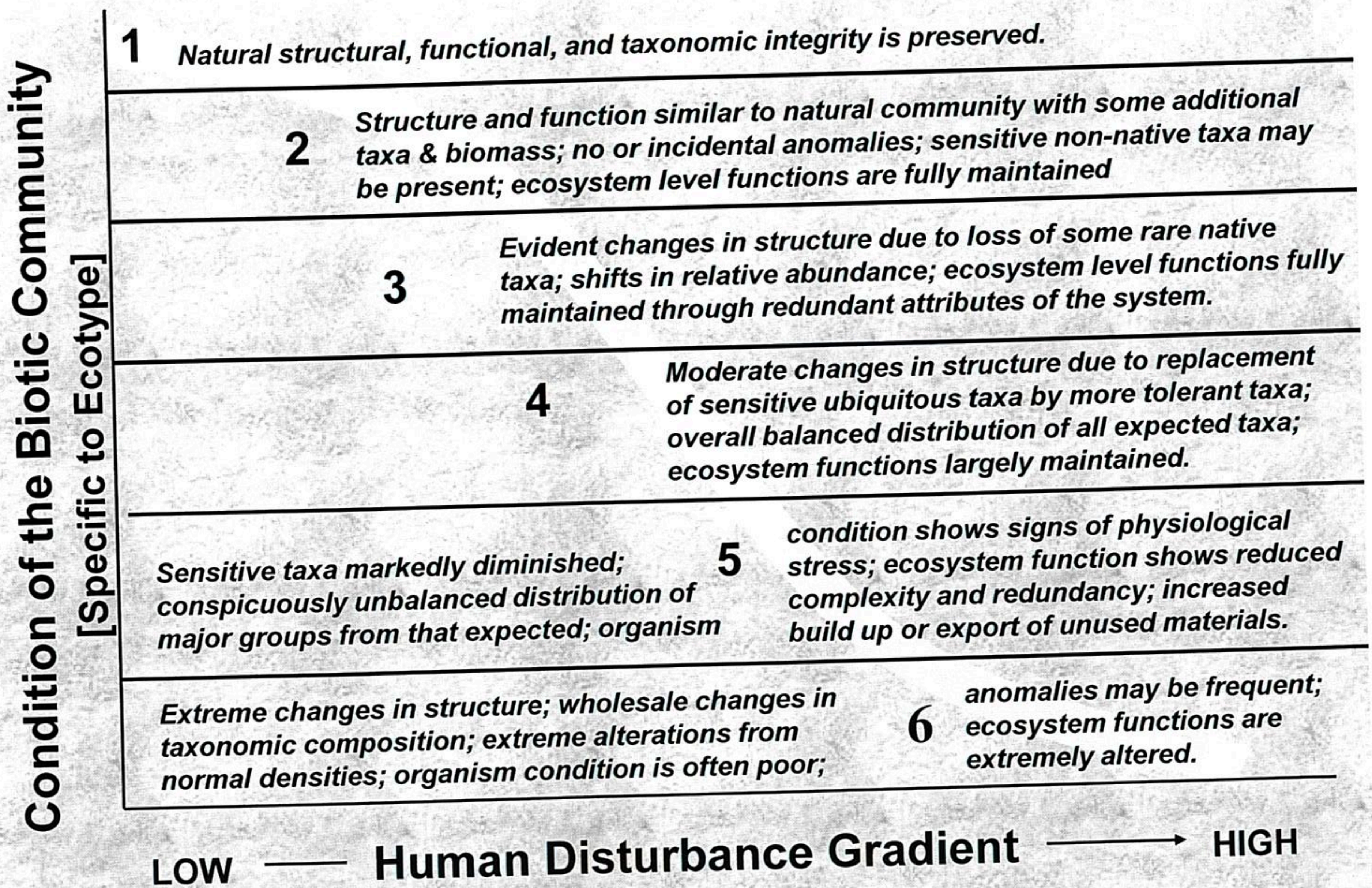
Biological Indicators: Stream Condition



Courtesy of Dave Allan, Univ of MIchigan


The Biological Condition Gradient – Concept
Natural structure & function of biotic community maintained
1
2
Minimal changes in structure & function
3
Evident changes in structure and minimal changes in function
4
Moderate changes in structure & minimal changes in function
5
Major changes in structure & moderate changes in function
6
Severe changes in structure & function
Biological Condition
Increasing Effect of Human Activity

Tiered Aquatic Life Use Conceptual Model: Draft Biological Tiers



Biological Condition Gradient Tiers

Ecological Attributes	1 Natural or native condition	2 Minimal changes in the structure of the biotic community and minimal changes in ecosystem function	3 Evident changes in structure of the biotic community and minimal changes in ecosystem function	4 Moderate changes in structure of the biotic community and minimal changes in ecosystem function	5 Major changes in structure of the biotic community and moderate changes in ecosystem function	6 Severe changes in structure of the biotic community and major loss of ecosystem function
	Native structural, functional and taxonomic integrity is preserved; ecosystem function is preserved within the range of natural variability	Virtually all native taxa are maintained with some changes in biomass and/or abundance; ecosystem functions are fully maintained within the range of natural variability	Some changes in structure due to loss of some rare native taxa; shifts in relative abundance of taxa but Sensitive-ubiquitous taxa are common and abundant; ecosystem functions are fully maintained through redundant attributes of the system	Moderate changes in structure due to replacement of some Sensitive-ubiquitous taxa by more tolerant taxa, but reproducing populations of some Sensitive taxa are maintained; overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes	Sensitive taxa are markedly diminished; conspicuously unbalanced distribution of major groups from that expected; organism condition shows signs of physiological stress; system function shows reduced complexity and redundancy; increased build-up or export of unused materials	Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities and distributions; organism condition is often poor; ecosystem functions are severely altered
I Historically documented, sensitive, long-lived or regionally endemic taxa	As predicted for natural occurrence except for global extinctions	As predicted for natural occurrence except for global extinctions	Some may be absent due to global extinction or local extirpation	Some may be absent due to global, regional or local extirpation	Usually absent	Absent
II Sensitive- rare taxa	As predicted for natural occurrence, with at most minor changes from natural densities	Virtually all are maintained with some changes in densities	Some loss, with replacement by functionally equivalent Sensitive-ubiquitous taxa	May be markedly diminished	Absent	Absent

Biological Condition Gradient Tiers

	1 Natural or native condition	2 Minimal changes in the structure of the biotic community and minimal changes in ecosystem function	3 Evident changes in structure of the biotic community and minimal changes in ecosystem function	4 Moderate changes in structure of the biotic community and minimal changes in ecosystem function	5 Major changes in structure of the biotic community and moderate changes in ecosystem function	6 Severe changes in structure of the biotic community and major loss of ecosystem function
III Sensitive-ubiquitous taxa	As predicted for natural occurrence, with at most minor changes from natural densities	Present and may be increasingly abundant	Common and abundant; relative abundance greater than Sensitive-rare, taxa	Present with reproducing populations maintained; some replacement by functionally equivalent taxa of intermediate tolerance.	Frequently absent or markedly diminished	Absent
IV Taxa of intermediate tolerance	As predicted for natural occurrence, with at most minor changes from natural densities	As naturally present with slight increases in abundance	Often evident increases in abundance	Common and often abundant; relative abundance may be greater than Sensitive-ubiquitous taxa	Often exhibit excessive dominance	May occur in extremely high OR extremely low densities; richness of all taxa is low
V Tolerant taxa	As naturally occur, with at most minor changes from natural densities	As naturally present with slight increases in abundance	May be increases in abundance of functionally diverse tolerant taxa	May be common but do not exhibit significant dominance	Often occur in high densities and may be dominant	Usually comprise the majority of the assemblage; often extreme departures from normal densities (high or low)

Biological Condition Gradient Tiers

	1	2	3	4	5	6
	Natural or native condition	Minimal changes in the structure of the biotic community and minimal changes in ecosystem function	Evident changes in structure of the biotic community and minimal changes in ecosystem function	Moderate changes in structure of the biotic community and minimal changes in ecosystem function	Major changes in structure of the biotic community and moderate changes in ecosystem function	Severe changes in structure of the biotic community and major loss of ecosystem function
VI Non-native or intentionally introduced taxa	Non-native taxa, if present, do not displace native taxa or alter native structural or functional integrity	Non-native taxa may be present, but occurrence has a non-detrimental effect on native taxa	Sensitive or intentionally introduced non-native taxa may dominate some assemblages (e.g. fish or macrophytes)	Some replacement of sensitive non-native taxa with functionally diverse assemblage of non-native taxa of intermediate tolerance	Some assemblages (e.g., fish or macrophytes) are dominated by tolerant non-native taxa	Often dominant; may be the only representative of some assemblages (e.g., plants, fish, bivalves)
VII Organism Condition (especially of long-lived organisms)	Any anomalies are consistent with naturally occurring incidence and characteristics	Any anomalies are consistent with naturally occurring incidence and characteristics	Anomalies are infrequent	Incidence of anomalies may be slightly higher than expected	Biomass may be reduced; anomalies increasingly common	Long-lived taxa may be absent; Biomass reduced; anomalies common and serious; minimal reproduction except for extremely tolerant groups
VIII Ecosystem Functions	All are maintained within the natural range of variability	All are maintained within the natural range of variability	Virtually all are maintained through functionally redundant system attributes; minimal increase in export except at high storm flows	Virtually all are maintained through functionally redundant system attributes though there is evidence of loss of efficiency (e.g., increased export or decreased import)	There is apparent loss of some ecosystem functions manifested as increased export or decreased import of some resources, and changes in energy exchange rates (e.g., P/R; decomposition)	Most functions show extensive and persistent disruption

Biological Condition Gradient Tiers

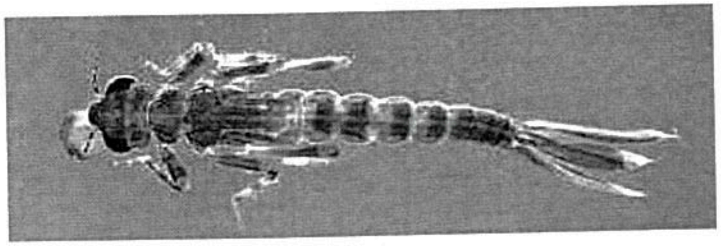
	1 Natural or native condition	2 Minimal changes in the structure of the biotic community and minimal changes in ecosystem function	3 Evident changes in structure of the biotic community and minimal changes in ecosystem function	4 Moderate changes in structure of the biotic community and minimal changes in ecosystem function	5 Major changes in structure of the biotic community and moderate changes in ecosystem function	6 Severe changes in structure of the biotic community and major loss of ecosystem function
IX Spatial and temporal extent of detrimental effects	N/A A natural disturbance regime is maintained	Limited to small pockets and short duration	Limited to the reach scale and/or limited to within a season	Mild detrimental effects may be detectable beyond the reach scale and may include more than one season	Detrimental effects extend far beyond the reach scale leaving only a few islands of adequate conditions; effect extends across multiple seasons	Detrimental effects may eliminate all refugia and colonization sources within the catchment and affect multiple seasons
X Ecosystem connectance	System is highly connected in space and time, at least annually	Ecosystem connectance is unimpaired	Slight loss of connectance but there are adequate local recolonization sources	Some loss of connectance but colonization sources and refugia exist within the catchment	Significant loss of ecosystem connectance is evident; recolonization sources do not exist for some taxa	Complete loss of ecosystem connectance in at least one dimension (i.e., longitudinal, lateral, vertical, or temporal) lowers reproductive success of most groups; frequent failures in reproduction & recruitment

Minimally disturbed, forested watershed

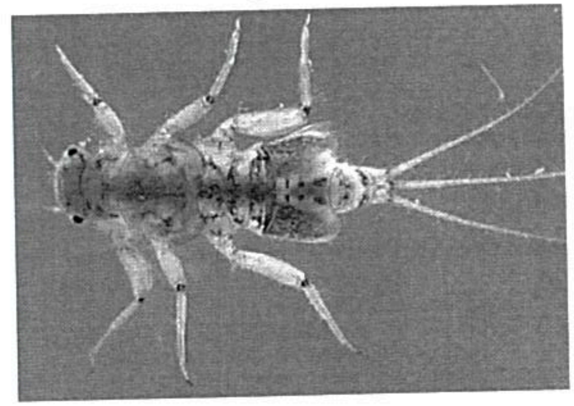
Courtesy of Susan Davies, ME DEP

Sensitive Organisms in Streams

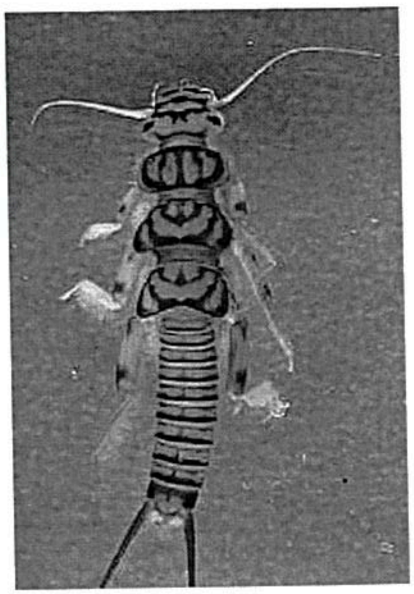
Dragonflies and Damselflies

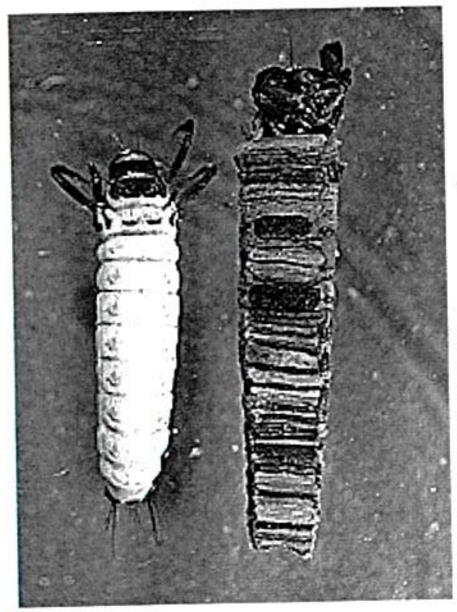


Mayflies

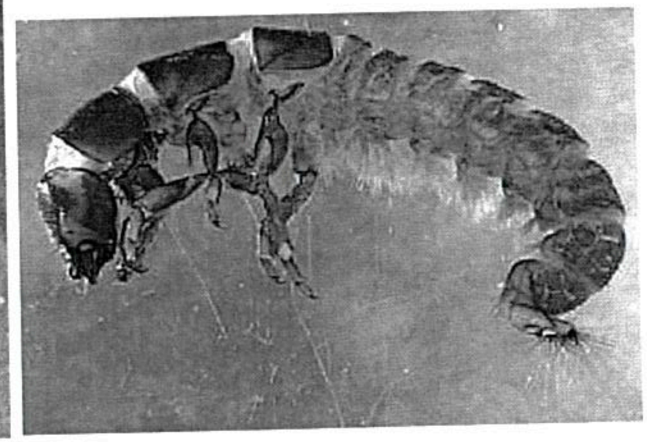


Stoneflies





Caddisflies

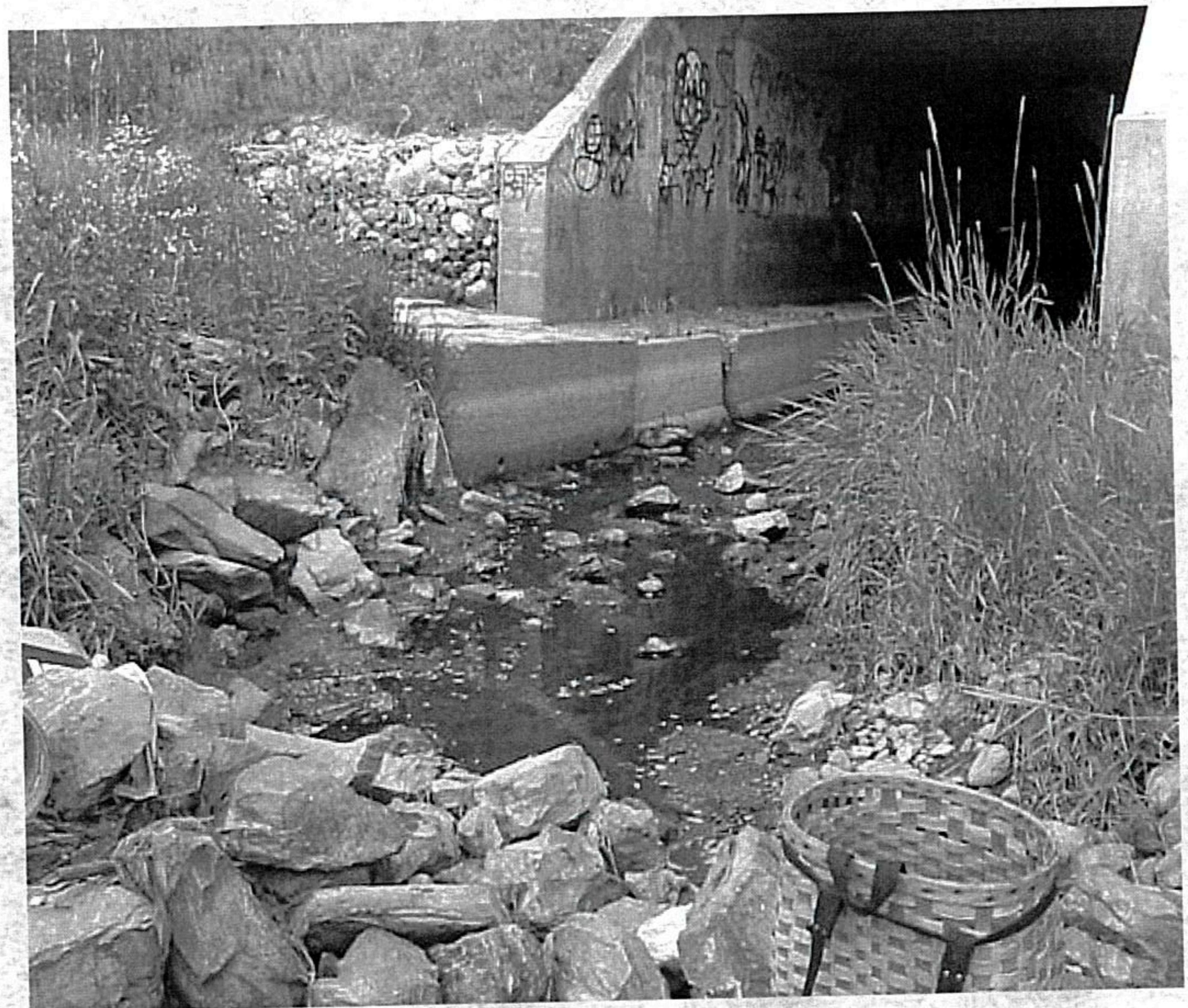


Expected Response to Stress: ↓ abundance & proportion

Courtesy of Chris Yoder, CABB

Stream through a cow pasture

Courtesy of Susan Davies, ME DEP

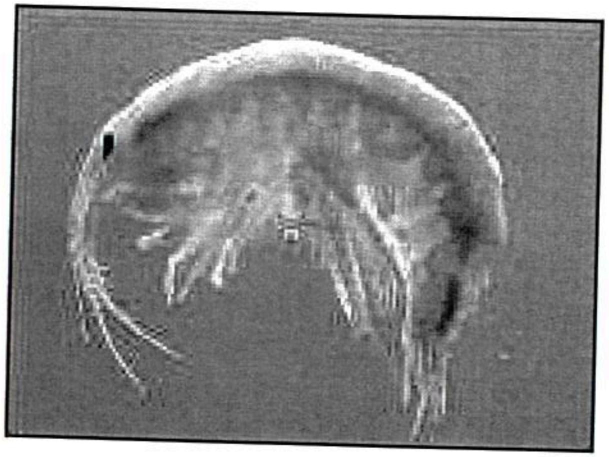


Stream draining a shopping mall

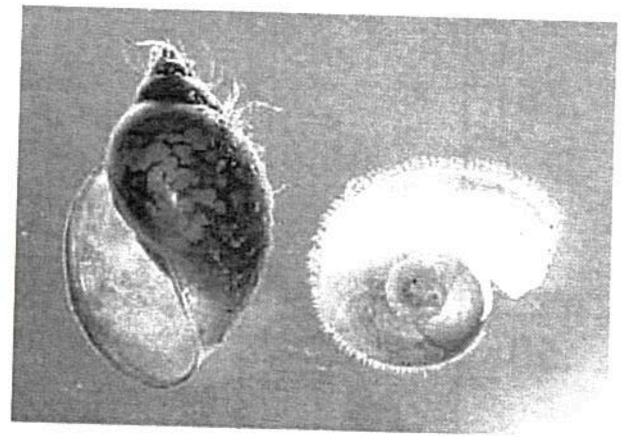
Courtesy of Susan Davies, ME DEP

Tolerant Organisms in Streams

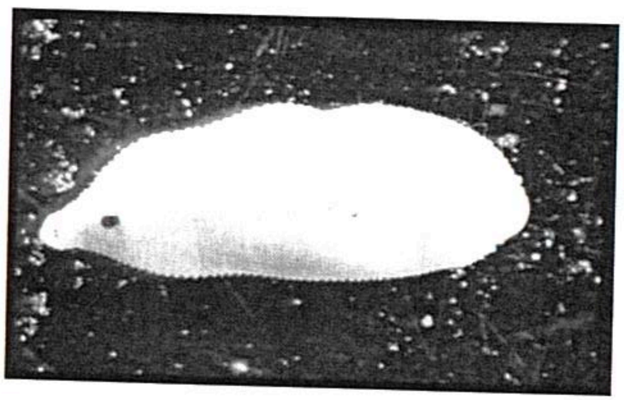
Scuds



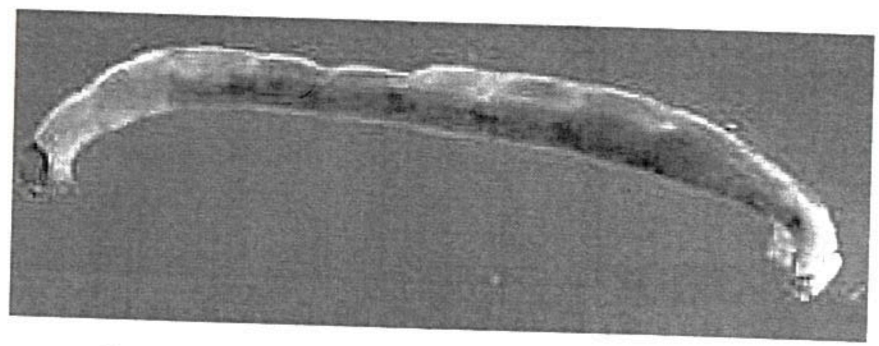
Snails



Leeches



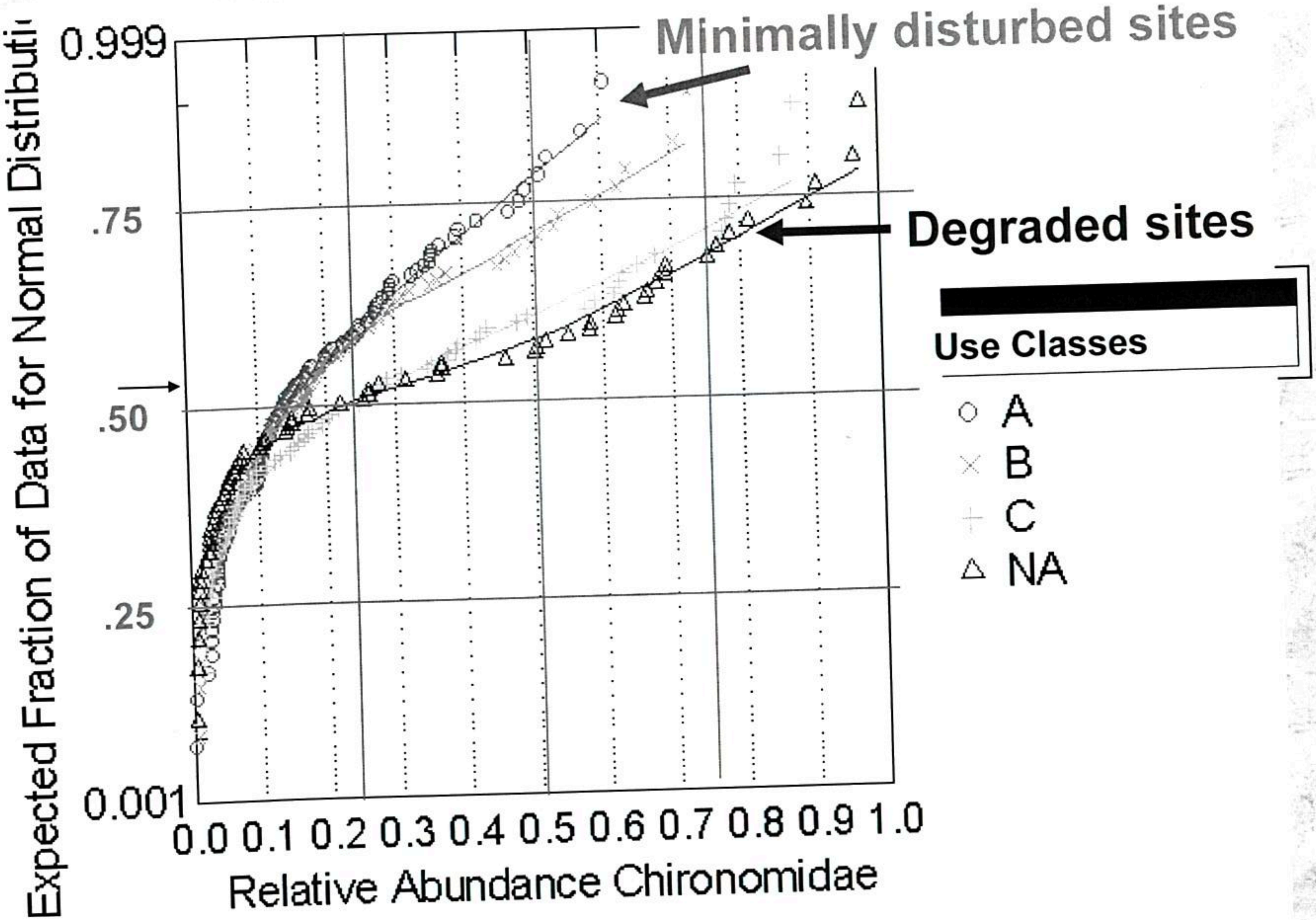
Midges



Expected Response to Stress: ↑ abundance & proportion

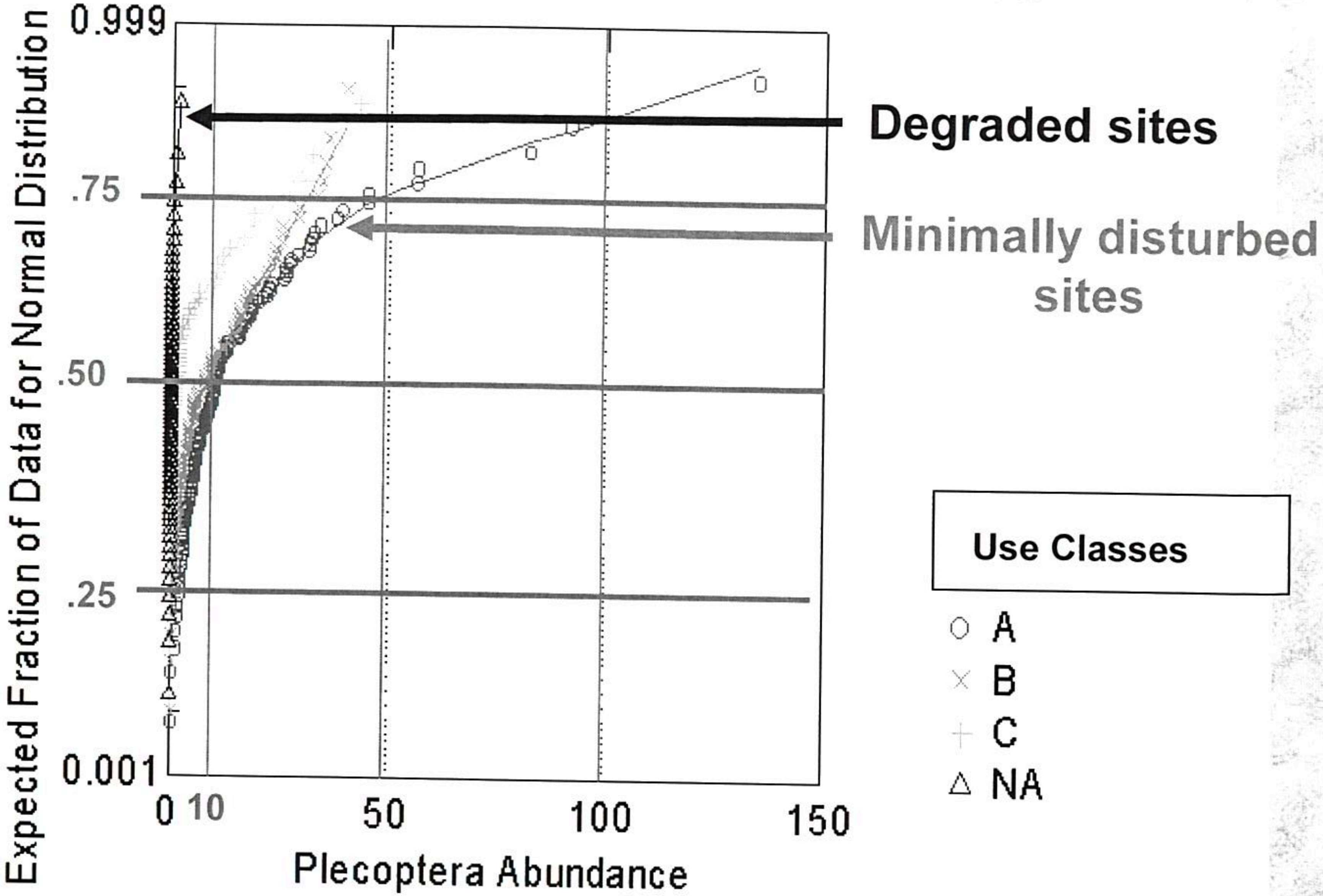
Courtesy of Chris Yoder, CABB

Maine Macroinvertebrate Monitoring Data



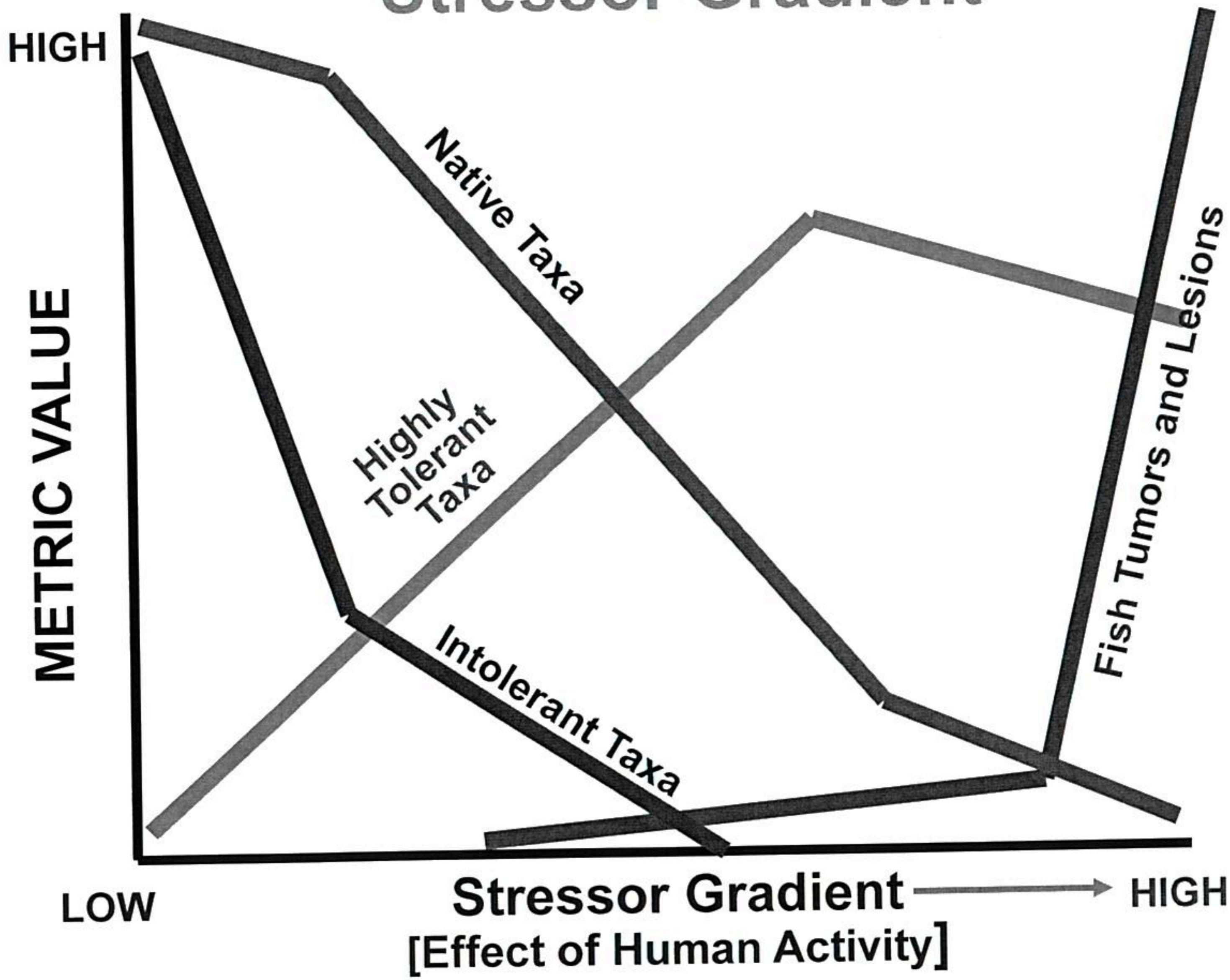
Courtesy of Susan Davies, MDEP

Maine Macroinvertebrate Monitoring Data



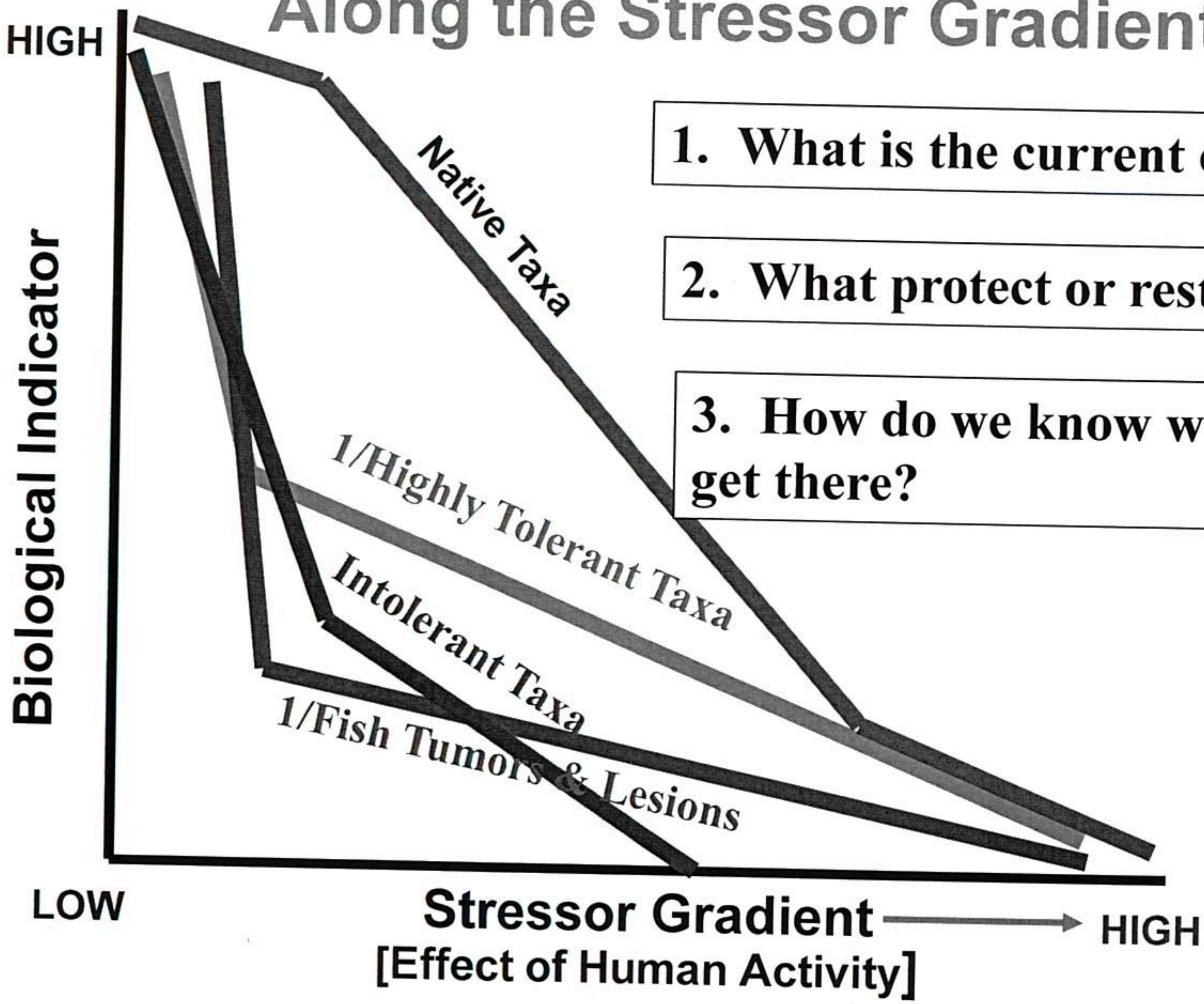
Courtesy of Susan Davies, MDEP

Metric Behavior Along the Stressor Gradient



Modified from Original Courtesy of Chris Yoder, CABB

Biological Indicator: Behavior Along the Stressor Gradient

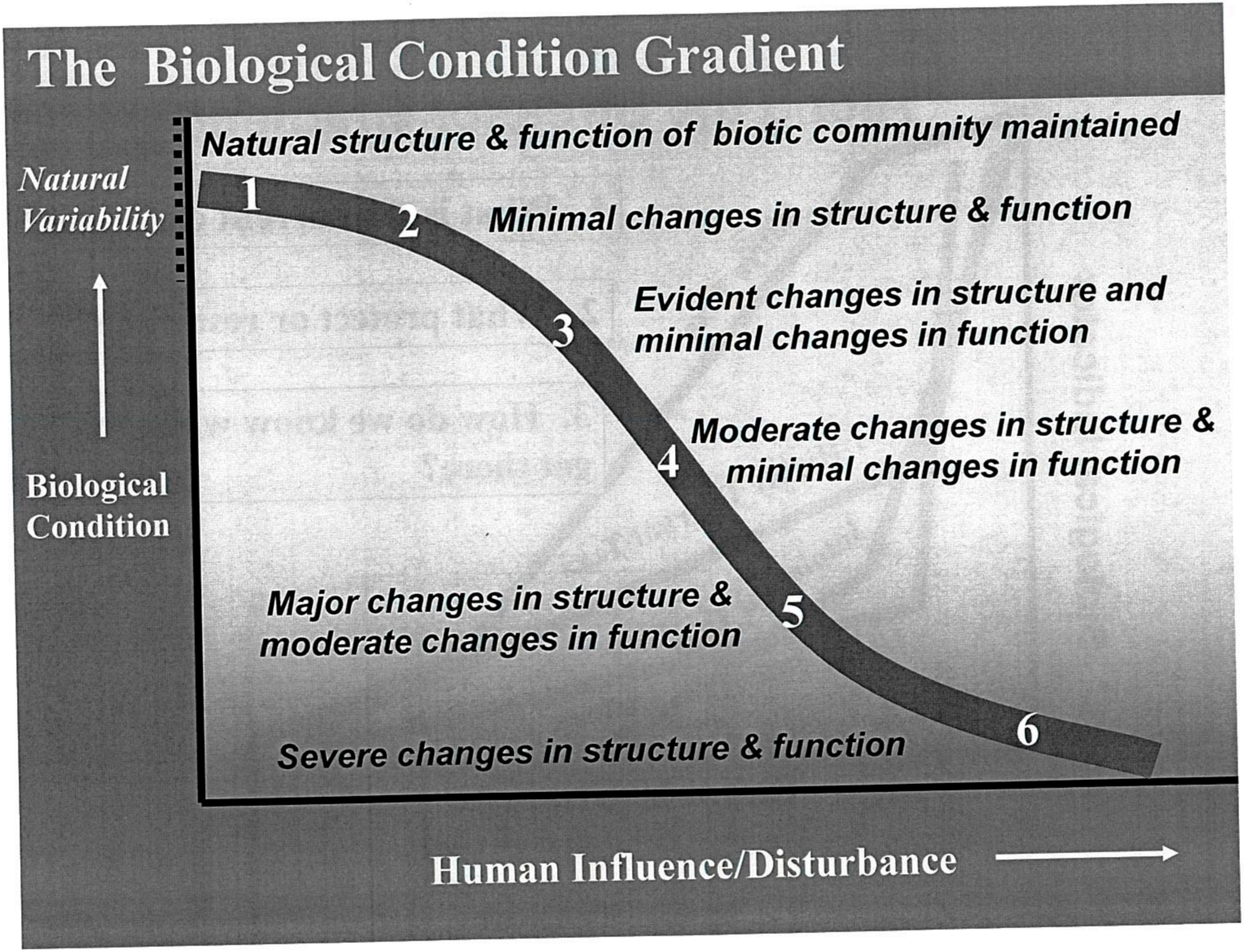


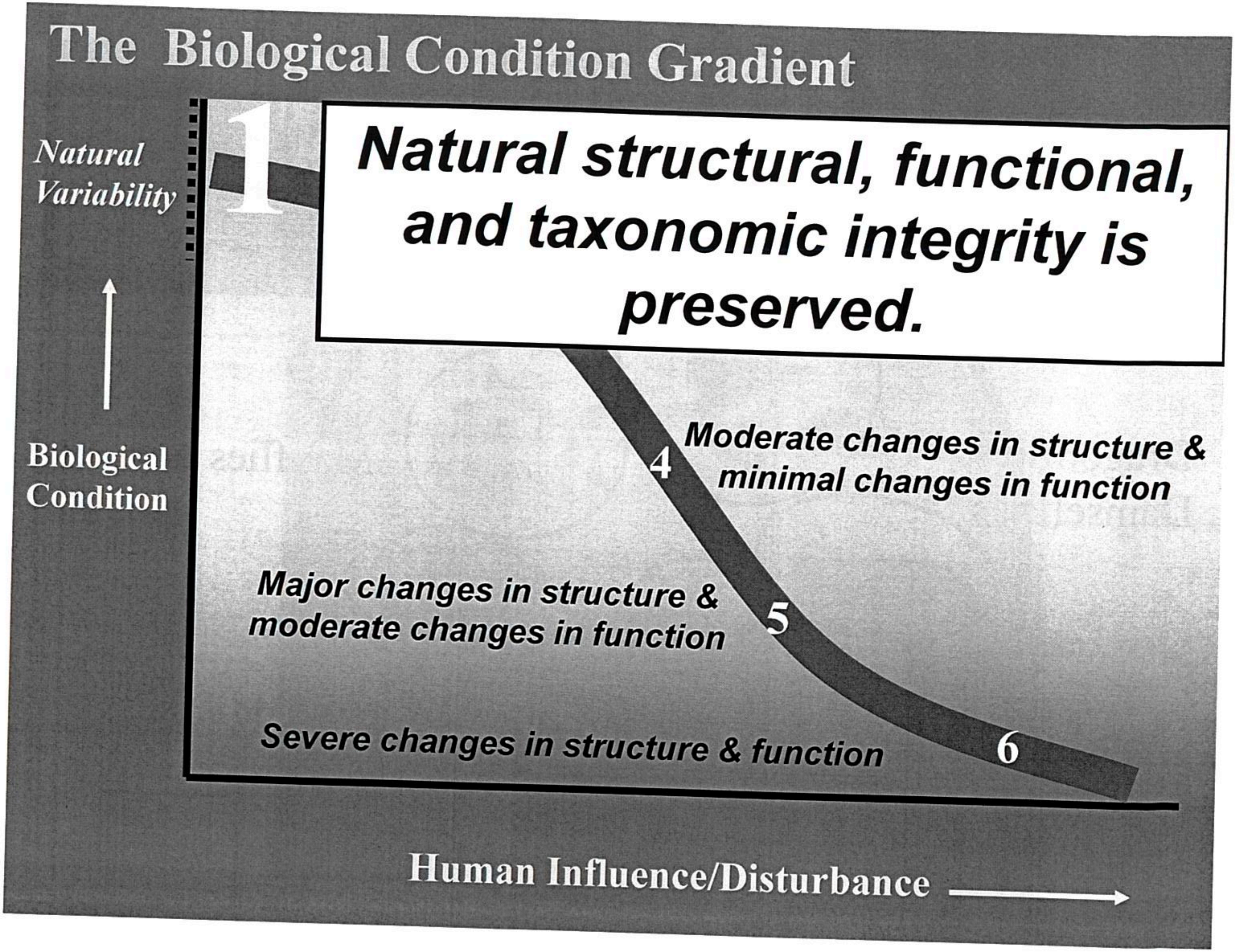
1. What is the current condition?

2. What protect or restore to?

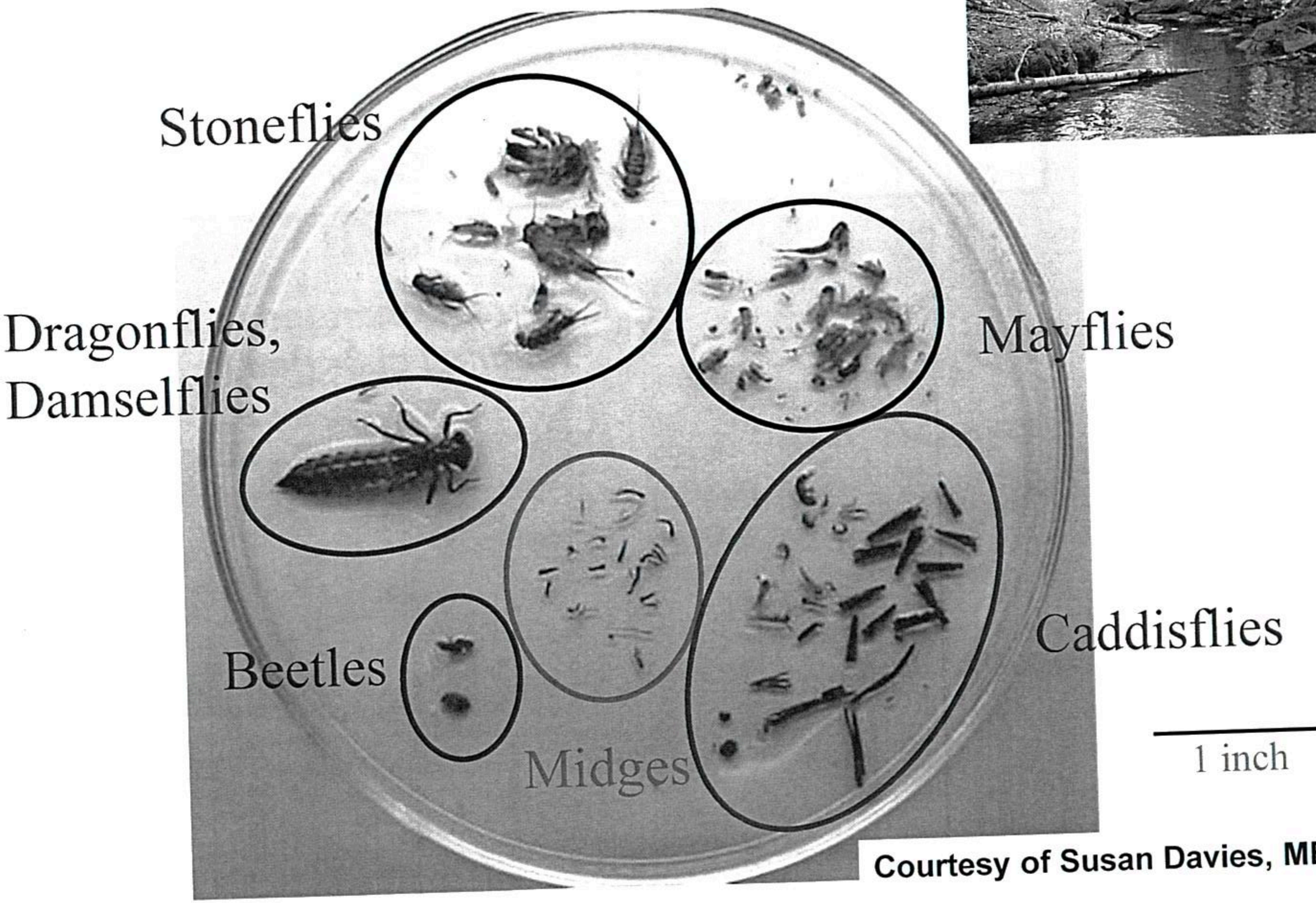
3. How do we know when we get there?

Modified from Original Courtesy of Chris Yoder, CABB

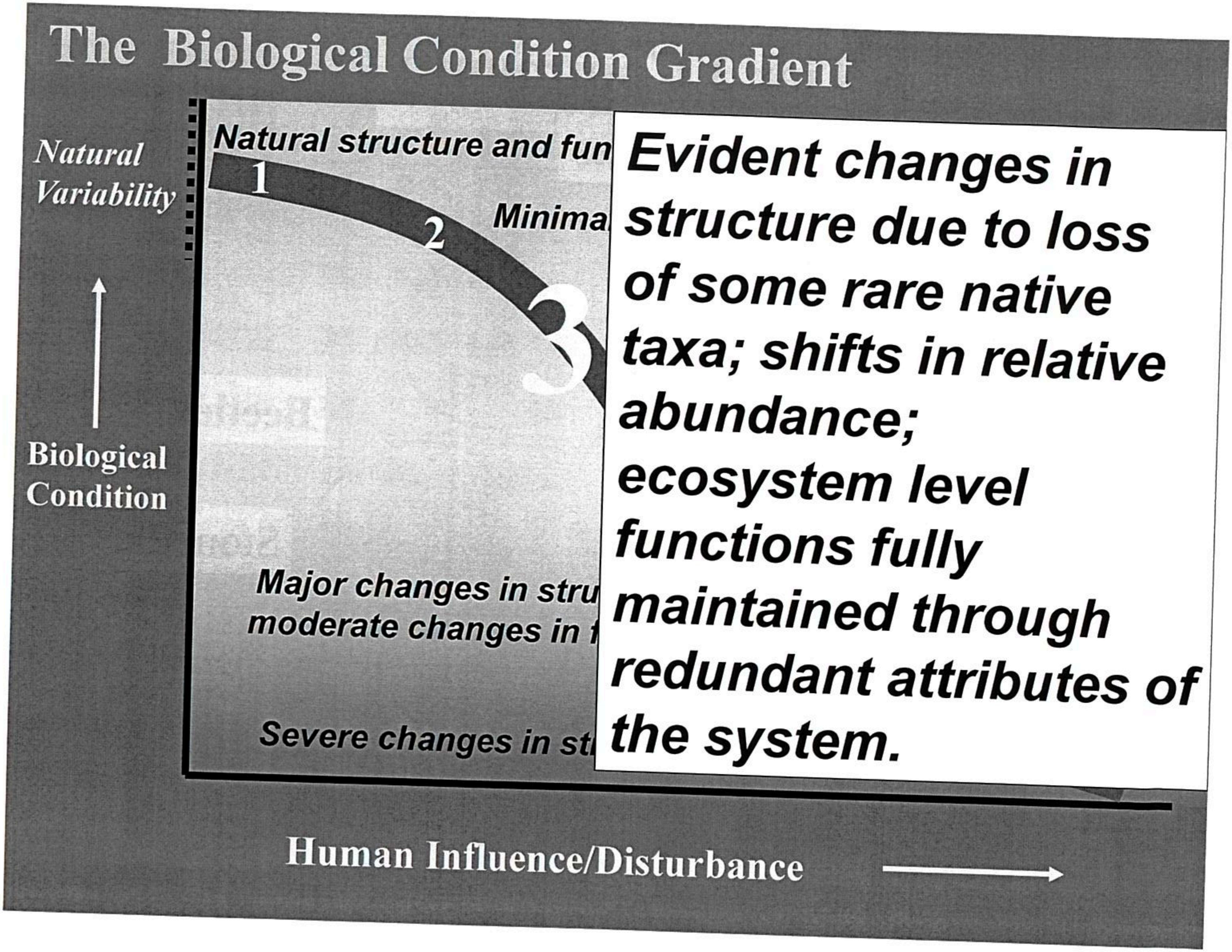

The Biological Condition Gradient
Natural structure & function of biotic community maintained
Natural Variability
1
2
Minimal changes in structure & function
3
Evident changes in structure and minimal changes in function
4
Moderate changes in structure & minimal changes in function
Biological Condition
Major changes in structure & moderate changes in function
5
6
Severe changes in structure & function
Human Influence/Disturbance


The Biological Condition Gradient
Natural Variability
Biological Condition
1
Natural structural, functional, and taxonomic integrity is preserved.
4
Moderate changes in structure & minimal changes in function
5
Major changes in structure & moderate changes in function
6
Severe changes in structure & function
Human Influence/Disturbance

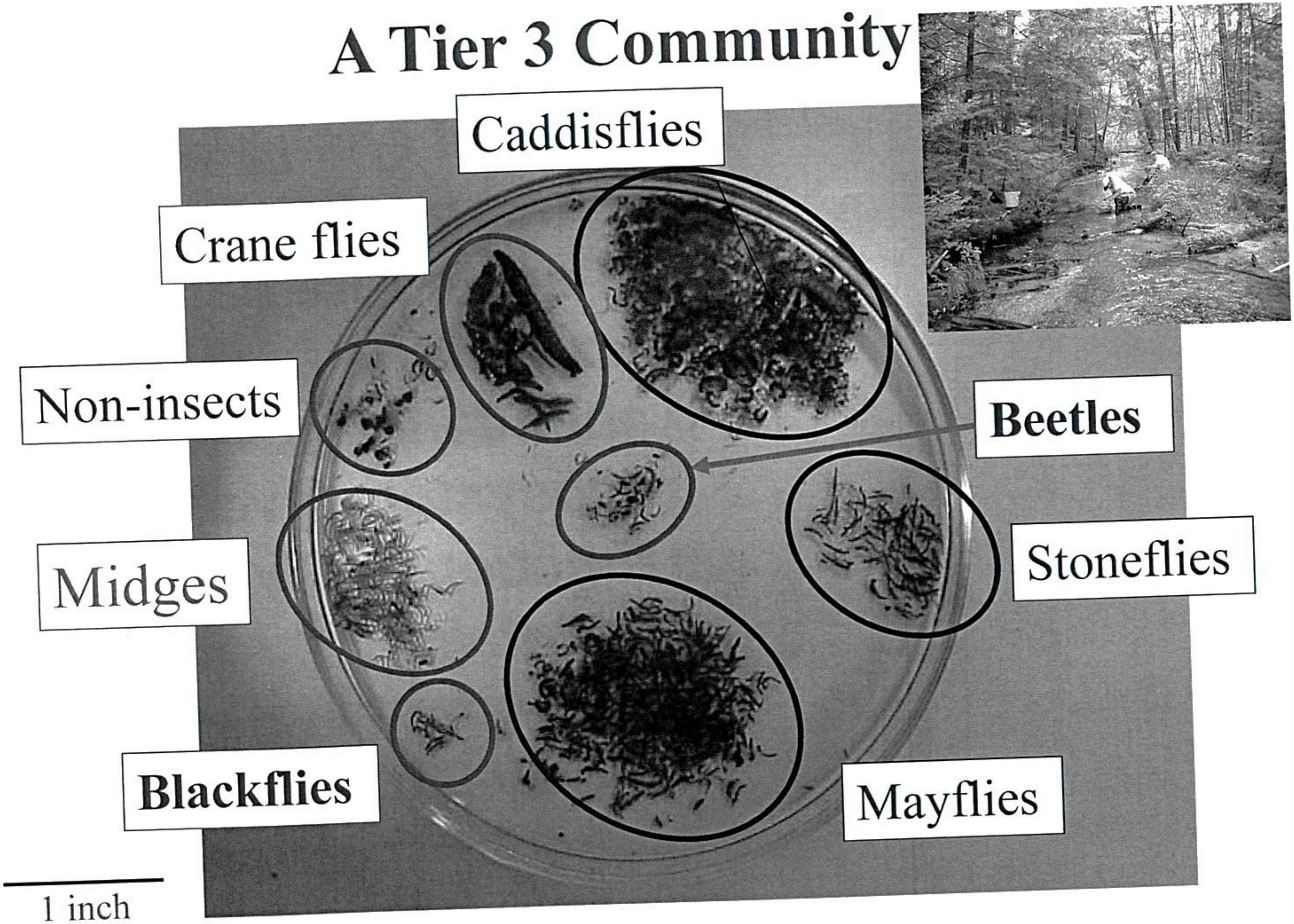
A BCG Level 1 Community



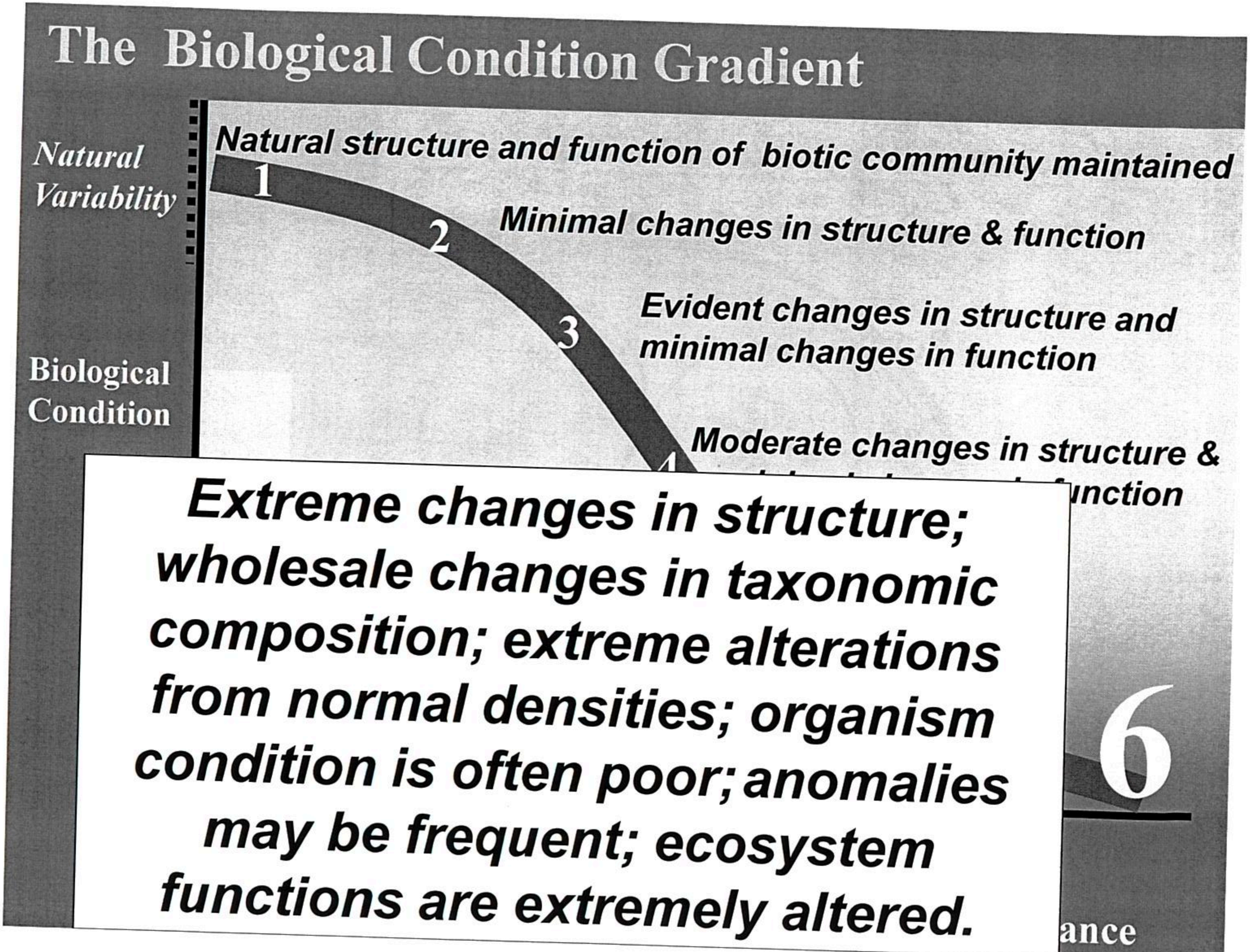
Courtesy of Susan Davies, ME DEP


The Biological Condition Gradient
Natural Variability
Biological Condition
Natural structure and fun
1
2
Minima
3
Major changes in stru
moderate changes in f
Severe changes in st
Evident changes in structure due to loss of some rare native taxa; shifts in relative abundance; ecosystem level functions fully maintained through redundant attributes of the system.
Human Influence/Disturbance

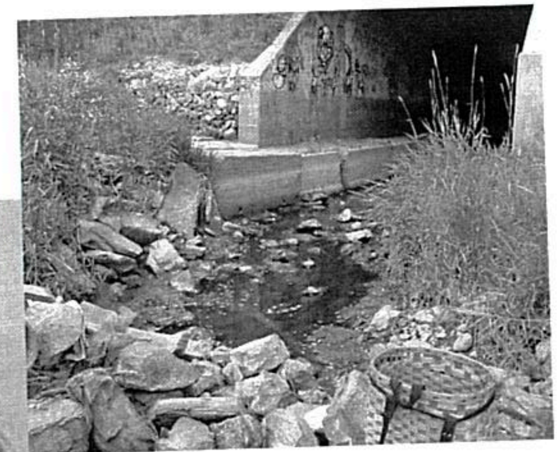
A Tier 3 Community

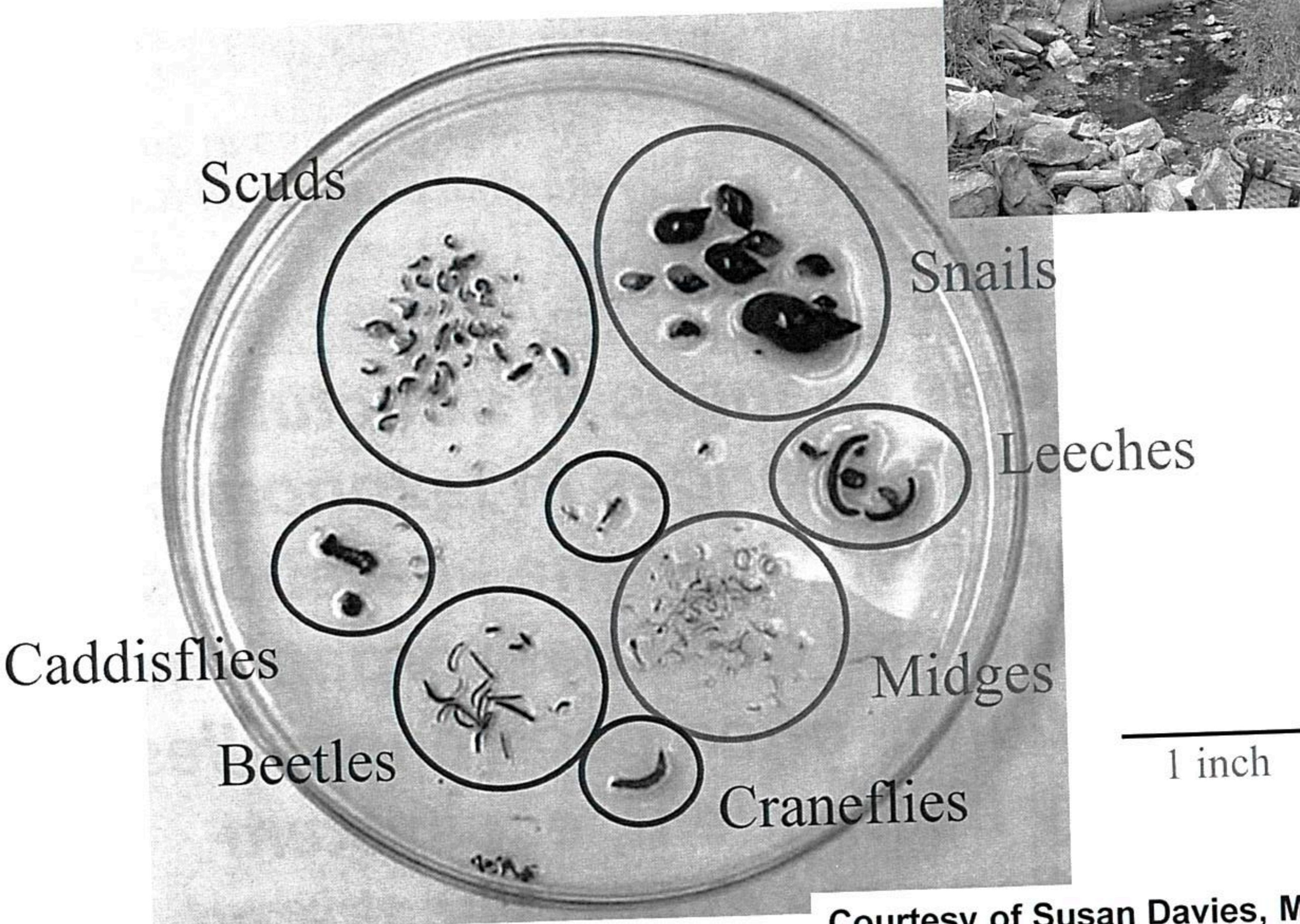


Courtesy of Susan Davies, ME DEP


The Biological Condition Gradient
Natural Variability
Biological Condition
Natural structure and function of biotic community maintained
1
Minimal changes in structure & function
2
Evident changes in structure and minimal changes in function
3
Moderate changes in structure &
6
Extreme changes in structure; wholesale changes in taxonomic composition; extreme alterations from normal densities; organism condition is often poor; anomalies may be frequent; ecosystem functions are extremely altered.

A Tier 5-6 Community

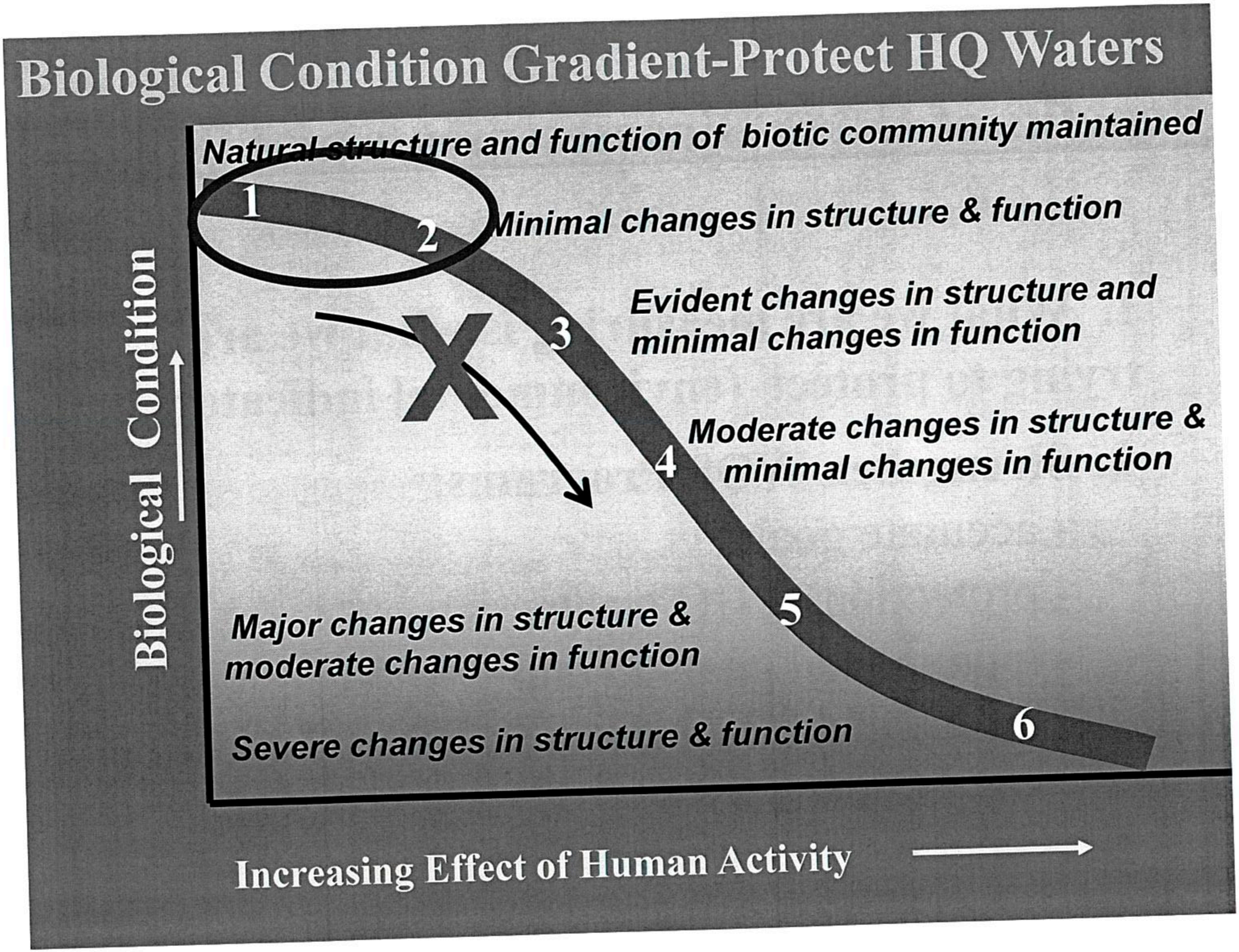


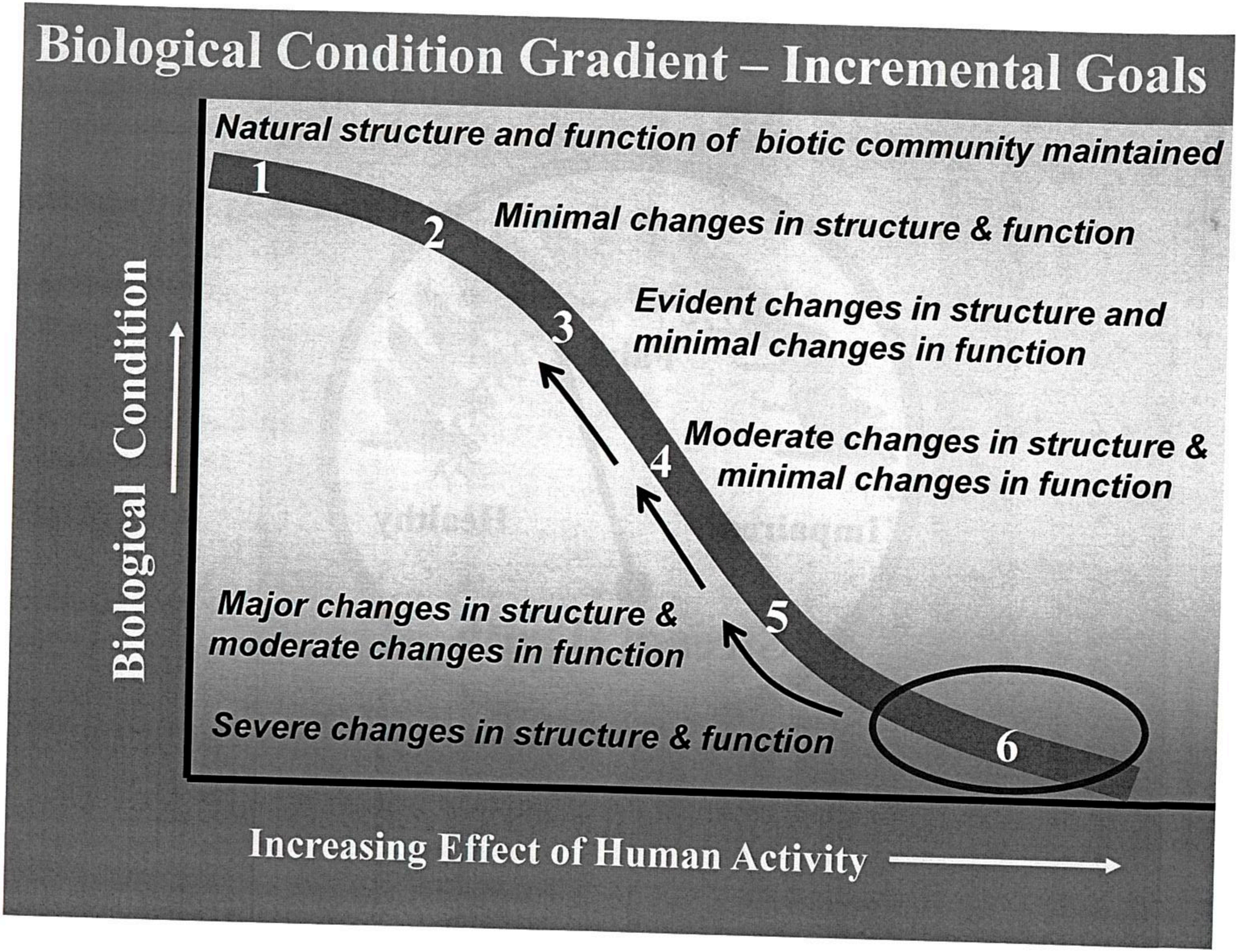


Courtesy of Susan Davies, ME DEP

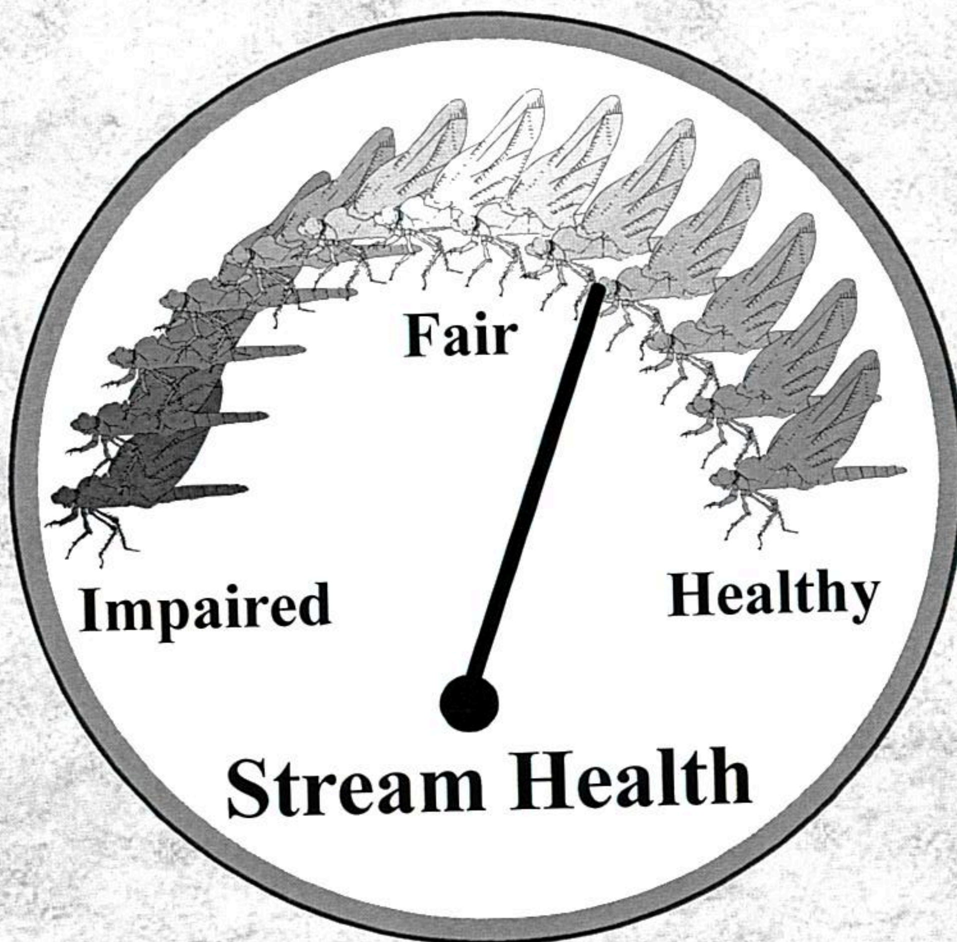
Benefits of Using Bioassessments and BCG

1. **What we are measuring is what we are trying to protect (environmental indicator)**
2. **Strengthen WQS Programs:**
   - accurate goals
   - protection of HQ waters
   - incremental goals to improve WQ
   - enhance public process and communication
   - support diagnosis


Biological Condition Gradient-Protect HQ Waters
Natural structure and function of biotic community maintained
1
2
Minimal changes in structure & function
Evident changes in structure and minimal changes in function
3
X
Moderate changes in structure & minimal changes in function
4
Major changes in structure & moderate changes in function
5
Severe changes in structure & function
6
Biological Condition
Increasing Effect of Human Activity

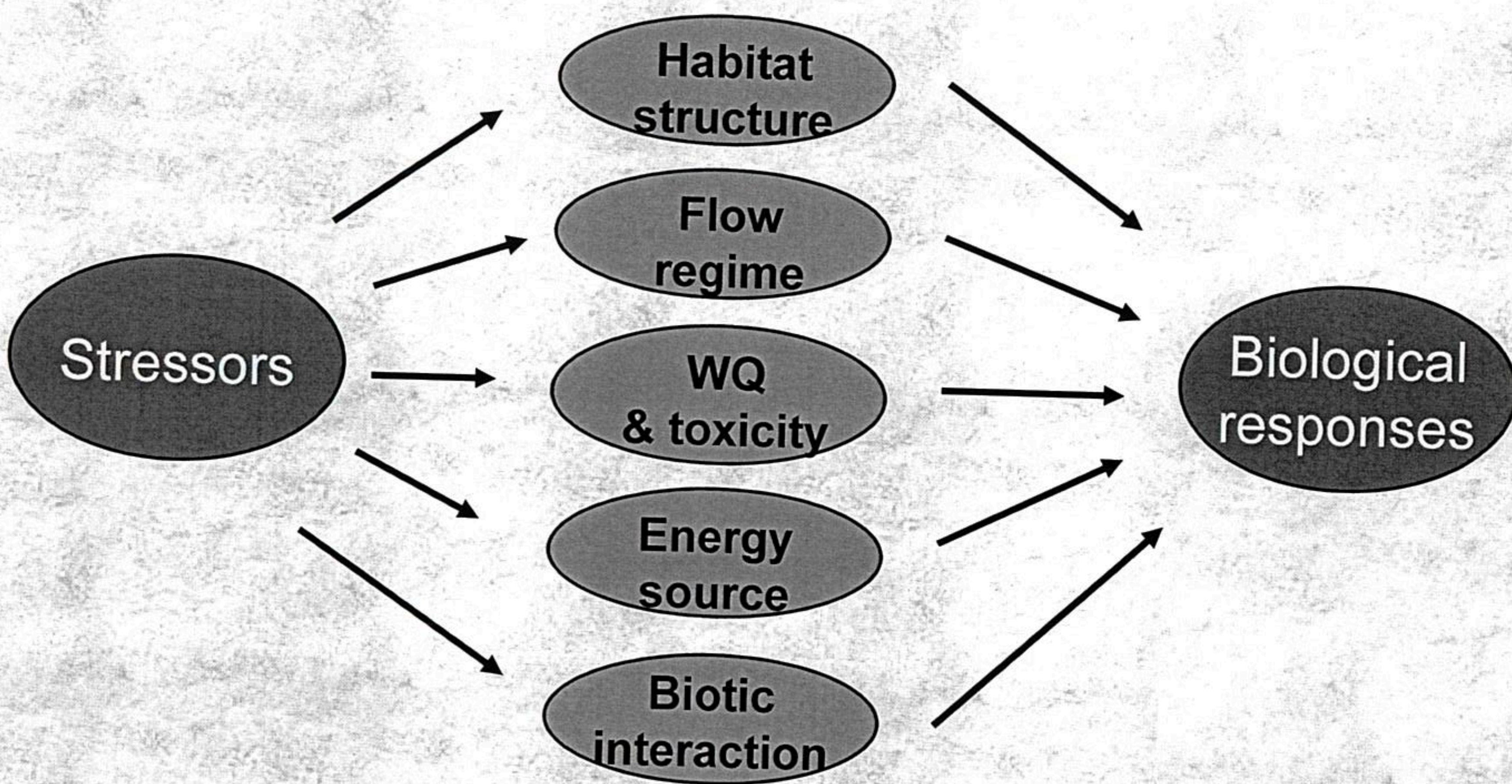

Biological Condition Gradient – Incremental Goals
Natural structure and function of biotic community maintained
Minimal changes in structure & function
Evident changes in structure and minimal changes in function
Moderate changes in structure & minimal changes in function
Major changes in structure & moderate changes in function
Severe changes in structure & function
1
2
3
4
5
6
Biological Condition
Increasing Effect of Human Activity

Enhance Public Communication



Florida "Bug O Meter"

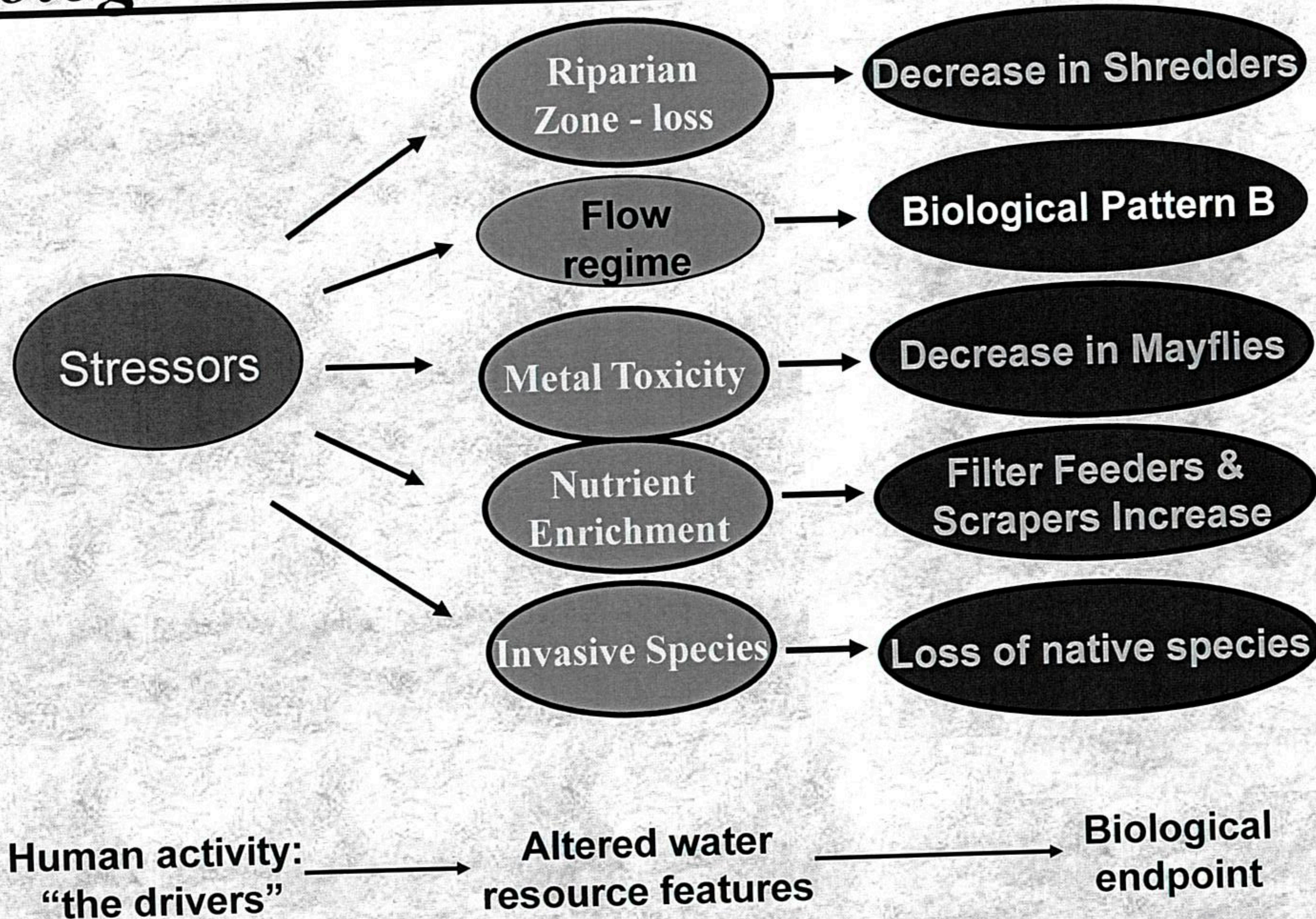
Biological Indicators Can Help Diagnosis



Human activity: "the drivers" → **Altered water resource features** → **Biological endpoint**

Courtesy of Dave Allan, Univ of MIchigan

Biological Indicators Can Help Diagnosis



Modified from Original Courtesy of Dave Allan, Univ of MIchigan

Jackson, Susank

From: Jackson, Susank
Sent: Thursday, April 04, 2013 4:41 PM
To: Dolan, Mary; Van Ness, Keith
Cc: Pond, Greg
Subject: RE: See slide number 2 for 10 Mile Creek Sites

Hello Mary,

I am guessing you are asking for photos and highlight for BCG level 3 since we show a level 2 and then 4 and then 6 but no 1 or 5 The intent was to show the range of change in biota and sites with the materials that we had available. We used petri plate slide photos that we had in stock, which were these levels (approximately 2, 4, 6).

If you would like a photo and graphics put together that include level 3, that could probably be done by working with Keith and digging into their sample vials. But, I am not sure if the Mo Co biological assessment program has the photo capability to do petri plate photos.

Keith – what do you think?

Greg, any thoughts on your part? Do you have photo capability at your lab?

Susan

From: Dolan, Mary [mailto:mary.dolan@montgomeryplanning.org]
Sent: Thursday, April 04, 2013 4:27 PM
To: Jackson, Susank
Subject: RE: See slide number 2 for 10 Mile Creek Sites

What about tier 3?

From: Jackson, Susank [mailto:Jackson.Susank@epa.gov]
Sent: Wednesday, April 03, 2013 2:52 PM
To: Dolan, Mary
Cc: Van Ness, Keith; Pond, Greg
Subject: See slide number 2 for 10 Mile Creek Sites

I spoke with Greg and Keith. Additional graphs can be developed over next several days to portray 10 Mile Creek position within full data site. What I did here was a simple mapping of the three Ten Mile Creek sites on the BCG. King Street is a first order tributary and there was no fish data, so invert result only. The sites above and below Old Baltimore Road are averaged fish and invert. I hope this graphic is not too simplistic. Revise as you wish re colors and adding/deleting text.

There were no other Ten Mile Creek Sites evaluated, but the group hoped to do more in the future.

Susan

From: Dolan, Mary [mailto:mary.dolan@montgomeryplanning.org]
Sent: Wednesday, April 03, 2013 12:16 PM
To: Jackson, Susank
Subject: RE: Please confirm you received the email with attachments

The BCG graphic would be helpful. Thanks.

From: Jackson, Susank [mailto:Jackson.Susank@epa.gov]
Sent: Wednesday, April 03, 2013 12:14 PM
To: Dolan, Mary; Van Ness, Keith; Pond, Greg
Cc: Symborski, Mark; Reynolds, Louis
Subject: RE: Please confirm you received the email with attachments

Hello, I just got out of a long meeting and catching up on emails.

The slides in the BCG/IBI comparison show where the 10 Mile Creek slides fall – recalling from memory, they were in a good quality category.

There is text in the report that discusses 10 mile creek sites including the potential for reintroduction of brook trout.

I can place the 10 mile creek sites on a BCG graphic if you would like. Let me know.

Susan

From: Dolan, Mary [mailto:mary.dolan@montgomeryplanning.org]
Sent: Wednesday, April 03, 2013 10:15 AM
To: Van Ness, Keith; Pond, Greg; Jackson, Susank
Cc: Symborski, Mark; Jeroen.Gerritsen@tetratech.com; Reynolds, Louis
Subject: RE: Please confirm you received the email with attachments

Thanks- I will see what I can pull from the slides.

Mary

From: Van Ness, Keith [mailto:Keith.VanNess@montgomerycountymd.gov]
Sent: Wednesday, April 03, 2013 9:47 AM
To: Pond, Greg; Dolan, Mary; Jackson, Susank
Cc: Symborski, Mark; Jeroen.Gerritsen@tetratech.com; Reynolds, Louis
Subject: RE: Please confirm you received the email with attachments

If I can help let me know – I think you and Susan have earned several weeks of well deserved rest. Again – thanks for all of this work – the report exceeds everything that I had hoped for!
Thanks
Keith

From: Pond, Greg [mailto:Pond.Greg@epa.gov]
Sent: Wednesday, April 03, 2013 9:43 AM
To: Dolan, Mary; Jackson, Susank
Cc: Symborski, Mark; Van Ness, Keith; Jeroen.Gerritsen@tetratech.com; Reynolds, Louis
Subject: RE: Please confirm you received the email with attachments

Mary, within the powerpoint sent (titled BCG and IBI correspondence) there is text describing aspects of TenMile Creek in relation to others (slides 3-5). If viewed as a slide show, the notes will not appear. Also in the conclusion of the report, I think bullet further 5 describes some rationale and evidence of why TMC is important and should be carefully planned. We intend to incorporate info from the data in the powerpoint slides into the report soon. Without a map, none of us ever saw the spatial context of where the 3 TMC sites were located (or any reach habitat or water chemistry data) so what we have elaborated upon is fairly basic (and without describing to you individual species level info filled with aquatic ecology jargon).

This is a final draft for now and we will send it out to all of the panelists for critical review. We will not be sending you any revisions until we've made them based on experts' review. We would like to add a lot more detail on TMC, but we as authors just didn't have anything else to go on from the quick workshop last week. At some point, it would be good to analyze data from several more subwatersheds within TMC to get a more complete picture.

Greg Pond
U.S. EPA Region III
Office of Monitoring and Assessment
Freshwater Biology Laboratory
1060 Chapline St.
Wheeling, WV 26003
Ph: 304-234-0243
pond.greg@epa.gov

From: Dolan, Mary [mailto:mary.dolan@montgomeryplanning.org]
Sent: Wednesday, April 03, 2013 9:24 AM
To: Jackson, Susank; Pond, Greg
Cc: Symborski, Mark; Van Ness, Keith; Jeroen.Gerritsen@tetratech.com; Reynolds, Louis
Subject: RE: Please confirm you received the email with attachments

I got it. Is this the final for now?

Please remember that the immediate use of this report (for Planning staff) is to understand the quality of the Ten Mile Creek sites in relation to the other sites and their place on the BCG. While I will be attaching the report, I only have one small paragraph relating to Ten Mile Creek from the report. I can prepare a map showing the location of the sites that were evaluated in the watershed, but I would like you to place the sites on the BCG continuum.

Can you elaborate a little on conditions in TMC and the differences between the mainstem sites 303band 304 and the King Tributary? You can do this outside the report.

Mary

From: Jackson, Susank [mailto:Jackson.Susank@epa.gov]
Sent: Wednesday, April 03, 2013 9:17 AM
To: Dolan, Mary; Pond, Greg
Cc: Symborski, Mark; Van Ness, Keith; Jeroen.Gerritsen@tetratech.com; Reynolds, Louis
Subject: Please confirm you received the email with attachments

I had a horrendous tussle with Workplace trying to get the draft report and attachments sent - took me 25 minutes to get this down between the system freezing and booting me out.

Please confirm if you have received the report and successful in opening.

Susan Jackson

From: Jackson, Susank
Sent: Wednesday, April 03, 2013 9:14 AM
To: Dolan, Mary; Pond, Greg
Cc: Symborski, Mark; Van Ness, Keith; Jeroen.Gerritsen@tetratech.com; Reynolds, Louis
Subject: Draft Report and attachments

Good morning. Attached is the draft report with two attachments (BCG and IBI comparison and Appendix B).

The report is preliminary. Your review comments are requested. We would like to finalize this report over the next month based on review by you and by the panelists.

Keith - can you review this report with a focus on the results and conclusions, provide us comments and then we can send to the expert panel for their review. Please email directly to Greg Pond and cc me. Greg is the "go to" technical person for this effort.

Both Greg and I will be available by email today if there are any changes or questions any of you on this draft. You may have some questions, edits or requests for further information for your meeting with the planning board tomorrow.

One last thing: If I recall correctly, there is a meeting next week. If you need a more final document by next week, please let us know. We can get the current draft cleaned abit more as well as the attachment formatted and incorporated directly into the body of the report. We would just need to know the timeframe.

Susan Jackson
US EPA Biological Criteria Program
